

## WORKS OF PROF. A. F. HOLLEMAN

PUBLISHED BY

JOHN WILEY & SONS.

### **A Text-book of Inorganic Chemistry.**

By Dr. A. F. HOLLEMAN, Professor Ordinarius in the University of Groningen, Netherlands. Rendered into English by HERMON C. COOPER, Ph.D., Instructor in Syracuse University, with the co-operation of the author. 8vo, viii + 458 pp., 84 figures. Cloth, \$2.50.

### **A Text-book of Organic Chemistry.**

Rendered into English from the Second Dutch Edition by A. JAMIESON WALKER, Ph.D. (Heidelberg), B.A., Head of Department of Chemistry, Municipal Technical College, Derby, Eng., assisted by OWEN E. MOTT, Ph.D. (Heidelberg), Demonstrator of Chemistry, Municipal Technical College, Derby, Eng., with the co-operation of the author. 8vo, xvii + 555 pages, 73 figures. Cloth, \$2.50.

A companion volume to the preceding, and forming with it a comprehensive treatise on pure Chemistry.

### **A Laboratory Manual of Organic Chemistry for Beginners.**

An Appendix to the Author's Text-book of Organic Chemistry. Translated from the Dutch by A. JAMIESON WALKER, Ph.D. (Heidelberg), B.A., Head of the Department of Chemistry, Technical College, Derby, England, With the Co-operation of the Author. 12mo, xiv + 78 pages. Cloth, \$1.00 net.

, A  
LABORATORY MANUAL  
OF  
ORGANIC CHEMISTRY  
FOR BEGINNERS.

BY  
DR. A. F. HOLLEMAN,  
*Professor Ordinarius in the University of Groningen, Netherlands,  
and Fellow of the Royal Academy of Sciences, Amsterdam.*

*AN APPENDIX TO THE AUTHOR'S TEXT-BOOK OF  
ORGANIC CHEMISTRY.*

TRANSLATED FROM THE DUTCH  
BY  
A. JAMIESON WALKER, Ph.D. (Heidelberg), B.A.,  
*Head of the Department of Chemistry, Technical College, Derby, England.*

WITH THE CO-OPERATION OF THE AUTHOR.

*FIRST EDITION.*

FIRST THOUSAND.

NEW YORK:  
JOHN WILEY & SONS.  
LONDON: CHAPMAN & HALL, LIMITED.

Copyright, 1904,  
BY  
A. JAMIESON WALKER.

---

*(Entered at Stationers' Hall.)*

ROBERT DRUMMOND, PRINTER, NEW YORK.

## AUTHOR'S PREFACE.

---

It is admitted universally that chemistry cannot be learnt by the study of text-books only, and that laboratory practice is essential. A student new to the science derives most benefit from a laboratory course of inorganic preparations, simple quantitative experiments, and qualitative inorganic analysis. He is brought thus into contact with work closely connected with the text-books and lectures on this division of chemistry, and is enabled to understand the subject much better than by any other method.

A student beginning the study of organic chemistry usually has to content himself with text-books and lectures, and very seldom has the opportunity of handling the compounds about which he has to read. There is, evidently, therefore, a lack in the methods of teaching the elements of organic chemistry adopted in the Universities.

Several years have elapsed since a course of practical work in organic chemistry was introduced into the Universities of the Netherlands, chiefly through the influence of Professor FRANCHIMONT of Leyden. This laboratory work is a complement to the lectures, and has proved very satisfactory.

At the suggestion of Dr. A. JAMIESON WALKER, the laboratory manual written by me in Dutch for this purpose is issued now in English. At his request, I have revised the whole text, and added some new experiments. In most instances I have indicated the weights or volumes suitable for the reactions, an



experience of many years having taught me that students always employ much larger quantities than are necessary. The amounts prescribed are approximate, and, to ensure the success of the experiments, need not be weighed or measured with great accuracy.

It should be mentioned that this manual is related intimately to my text-book of organic chemistry, and constitutes an appendix to it. To obtain the maximum advantage from these experiments, I advise the student first to study them with the aid of the text-book, and afterwards to carry them out in the laboratory. This is the only method by which he can attain to a thorough comprehension of his laboratory work.

A. F. HOLLEMAN.

GRONINGEN, NETHERLANDS, March, 1904.

## TRANSLATOR'S PREFACE.

---

DURING the few months the English edition of Professor HOLLEMAN'S "Text-book of Organic Chemistry" has been published, it has taken a foremost place among works on the science for students' use. The volume now issued constitutes an appendix to the text-book, and forms an introductory guide to laboratory work in organic chemistry, as well as a compendium of experiments suitable for lecture-table illustration.

The translation is from a completely revised and considerably extended copy of the Dutch edition, specially prepared by Professor HOLLEMAN for the purpose. To facilitate reference, I have added paragraph headings, and all the manuscript and proof-sheets have been corrected by the author, to whom I am much indebted for his careful revision.

References in the text printed in Clarendon type are to my translation of Professor HOLLEMAN'S "Leerboek der Organische Chemie," and those to "Inorganic Chemistry" to Dr. COOPER'S translation of his "Leerboek der Anorganische Chemie," published by Messrs. JOHN WILEY and SONS.

My thanks are due to the publishers for the care they have bestowed on the production of the work.

A. JAMIESON WALKER.

DERBY, ENGLAND, April, 1904.



# CONTENTS.

---

Light figures refer to pages; Clarendon figures to the author's "Text-book of Organic Chemistry."

	PAGE
<b>I. QUALITATIVE ANALYSIS OF CARBON COMPOUNDS (3-8) . . . . .</b>	<b>1</b>
<i>Detection of Carbon and Hydrogen (3) . . . . .</i>	1
Carbonization, 1. Oxidation with copper oxide, 1.	
<i>Detection of Nitrogen (4) . . . . .</i>	2
LASSAIGNE'S method, 2. WILL and VARRENTRAP'S method, 2. KJELDAHL'S method, 2.	
<i>Detection of the Halogens (5) . . . . .</i>	2
BEILSTEIN'S test, 2. Calcium-oxide test, 3.	
<i>Detection of Sulphur (5) . . . . .</i>	3
CARIUS' test, 3. Caustic-alkali test, 3.	
<b>II. THE ALLOTROPIC MODIFICATIONS OF CARBON (16) . . . . .</b>	<b>4</b>
Graphite, 4. Wood-charcoal, 4. Bone-charcoal, 4.	
Decolourization of solutions by bone-charcoal, 4. Absorption of lead salts by bone-charcoal, 4. Decolourizing action of bone-charcoal, 5.	
<b>III. LABORATORY METHODS (18-27) . . . . .</b>	<b>5</b>
Fractional distillation, 5. Steam distillation, 5. Extraction with solvents, 6. Determination of the melting-point, 6. Determination of the boiling-point, 7. Crystallization, 7.	
<b>IV. SATURATED HYDROCARBONS (29-42) . . . . .</b>	<b>7</b>
Preparation of methane, 7. Distillation of petroleum, 8. Inflammability of petroleum-vapour, 8. Stability of the saturated hydrocarbons, 8.	
<b>V. ALCOHOLS, <math>C_nH_{2n+1}\cdot OH</math> (43-55) . . . . .</b>	<b>9</b>
Action of sodium upon alcohol, 9. Fusel oil, 9. Wine, 9. Heat developed by mixing alcohol and water, 9. Test for water in alcohol, 9. Separation of water from alcohol, 10. Oxidation of ethyl alcohol, 10.	

	PAGE
VI. ALKYL HALIDES, ESTERS, AND ETHERS (56-64).....	10
Ethyl chloride, 10. Ethylsulphuric acid, 10. Diethyl ether, 11. Ethylmercaptan, 12.	
VII. AMINES AND NITRO-COMPOUNDS (69-77).....	12
<i>Amines</i> (69-74).....	12
Methylamine, 12. Carbylamine reaction, 12. Mustard-oil reaction, 12. Reaction with copper salts, 12. Nitrous-acid test, 13. Nitrosamines, 13. Dimethylamine and trimethylamine, 14.	
<i>Nitro-compounds</i> (75-77).....	14
Sodium nitromethane, 14. Nitrolic-acid reaction, 14. Reduction of nitro-compounds, 14.	
VIII. NITRILES AND ISONITRILES (83-85).....	14
Preparation, 14. Hydrolysis of nitriles, 15.	
IX. SATURATED ACIDS, $C_nH_{2n}O_2$ ; AND ESTERS (86-92, 97).....	15
Formic acid, 15. Decomposition of mercuric formate, 15. Action of concentrated sulphuric acid on formic acid, 16. Oxidation of formic acid by potassium permanganate, 16. Cacodyl test for acetic acid, 16. Stability of acetic acid towards oxidizing-agents, 17. Silver acetate, 17. Test for acetic acid, 17. Oxidation of ethyl alcohol to acetic acid, 17. Saponification of butter, 18. Calcium and lead salts of the higher fatty acids, 18. Volatile fatty acids, 18. Higher fatty acids, 18. Soap, 19. Ethyl acetate, 19. Velocity of saponification of ethyl acetate, 19. Solubility of ethyl acetate in water, 19.	
X. ALDEHYDES AND KETONES (106-121).....	20
<i>Aldehydes</i> (106-118).....	20
Acetaldehyde. 20. Silver-mirror test. 20. Aldehyde-	

	PAGE
test for the double bond, 23. Explosive mixture of ethylene and oxygen, 23. Unsaturated hydrocarbons in coal-gas, 23. Double linking in amylene, 23.	
<i>Acetylene</i> (132 and 133) .....	23
Preparation of acetylene, 23. Copper acetylene and silver acetylene, 23.	
XII. MONOBASIC UNSATURATED ACIDS (139-144) .....	24
Double bond in almond oil, 24. Oleic acid from almond oil, 24. Elaidic transformation, 24. Fusion of oleic acid with caustic soda, 24. Lead oleate, 25.	
XIII. CHLOROFORM AND IODOFORM (150-152) .....	25
Preparation of chloroform, 25. Action of caustic potash on chloroform, 25. Conversion of chloroform into potassium cyanide, 25. Chloroform and silver nitrate, 26. Iodoform test for alcohol, 26.	
XIV. GLYCEROL (157-160) .....	26
Preparation of allyl alcohol, 26. Test for glycerol, 26. Action of alkalis on copper salts in presence of glycerol, 26. BAUMANN and SCHOTTEN's test for hydroxyl-groups, 27.	
XV. SATURATED DIBASIC ACIDS (163-167) .....	27
<i>Oxalic Acid</i> (165) .....	27
Preparation of oxalic acid from wood, 27. Conversion of formates into oxalates, 27. Calcium, lead, and copper oxalates, 28. Decomposition of calcium oxalate by heat, 28. Decomposition of lead and copper oxalates by heat, 28. Action of concentrated sulphuric acid on oxalic acid, 28. Complex oxalates, 29. Dimethyl oxalate, 29. Diethyl oxalate, 29. Oxamide, 29.	
<i>Succinic Acid</i> (167) .....	30
Barium succinate, 30. Basic ferric succinate, 30. Succinimide, 30.	
XVI. HYDROXY-ACIDS OR ALCOHOL-ACIDS (182-198) .....	30
<i>Lactic Acid</i> (185) .....	30
Decomposition of lactic acid by dilute sulphuric acid, 30. Decomposition of lactic acid by concentrated sulphuric acid, 30. Test for hydroxyl-groups with phosphorus pentachloride, 31.	
<i>Tartaric Acid</i> (192-197) .....	31
Potassium tartrates, 31. Iron ammonium tartrate, 31.	

	PAGE
FEHLING'S solution, 31. Action of heat on tartaric acid, 32. Microchemical method of distinguishing between tartaric acid and racemic acid, 32. Tartar emetic, 32.	
<i>Citric Acid</i> (198) .....	32
Preparation from lemons, 32. Action of concentrated sulphuric acid on citric acid, 32.	
XVII. CHLORAL HYDRATE (204) .....	33
Action of water on chloral, 33. Action of caustic potash on chloral hydrate, 33. Silver-mirror test for chloral hydrate, 33.	
XVIII. ALDEHYDE AND KETONE ALCOHOLS OR SUGARS (206-231). 33	
<i>Properties of the Monoses</i> (208) .....	33
Silver-mirror test, 33. Resinification with caustic alkalis, 34. Reduction of FEHLING'S solution, 34. Osazones, 34.	
<i>Methods of Formation of the Monoses</i> (210) .....	34
Inversion of sucrose (cane-sugar), 34. Glycerose, 34.	
<i>Pentoses</i> (211) .....	34
Furfuraldehyde test, 34.	
<i>Hexoses</i> (212) .....	35
Hydrochloric-acid test, 35.	
<i>d</i> -Glucose (212, 1) .....	35
Calcium alkoxide of <i>d</i> -glucose, 35. Glucosesulphuric acid, 35. Copper alkoxide of <i>d</i> -glucose, 35. Detection of <i>d</i> -glucose in urine, 36. Oxidation of <i>d</i> -glucose by nitric acid, 36.	
<i>d</i> -Fructose (212, 2) .....	36
Alcoholic character, 36. Test for <i>d</i> -fructose, 36.	

	PAGE
Starch-paste, 38. Properties distinguishing starch from the monoses, 38. Conversion of starch into <i>d</i> -glucose, 38. Iodine test for starch, 38. Barium alkoxide of starch, 38. Conversion of starch into dextrin, 38. Potato-starch, 39.	
Cellulose (229-231) .....	39
Hydrolysis of cellulose, 39. Parchment-paper, 39. Solubility of cellulose in SCHWEITZER's reagent, 39. Nitrates of cellulose, 39. Detection of lignin in paper, 40.	
XIX. HYDROCYANIC ACID AND ITS SIMPLE AND COMPLEX SALTS (242 and 243) .....	40
Hydrocyanic acid, 40. Prussian-blue test, 40. Silver cyanide, 40. Hydrolysis of potassium cyanide, 41. Conversion of ammonium formate into hydrocyanic acid, 41. Double ferrocyanide of potassium and calcium, 41. Ferrocyanic acid, 41. Action of concentrated sulphuric acid on potassium ferrocyanide, 41. Potassium ferricyanide, 41. Reduction of potassium ferricyanide, 42. Oxidation of potassium ferrocyanide by potassium permanganate, 42.	
XX. POTASSIUM CYANATE AND POTASSIUM THIOCYANATE (244 and 245) .....	42
Potassium cyanate, 42. Potassium thiocyanate, 42. Silver thiocyanate, 42.	
XXI. DERIVATIVES OF CARBONIC ACID (248-256) .....	43
Carbon Disulphide (250) .....	43
Inflammability, 43. Volatility, 43. Solvent power, 43. Barium trithiocarbonate, 43. Potassium and copper salts of xanthic acid, 43.	
Urea (252 and 253) .....	44
WÖHLER's synthesis, 44. Urea oxalate, 44. Urea nitrate from urine, 44. KNOP's method for the estimation of urea in urine, 44. BUNSEN's method for the estimation of urea in urine, 44. LIEBIG's method for the estimation of urea in urine, 44. Action of heat on urea, 45. Cyanuric acid, 45.	
Carbamic Acid (254) .....	45
Calcium carbamate, 45. Ammonium dithiocarbamate, 45.	
XXII. URIC ACID GROUP (257 and 258) .....	46



	PAGE
Ammonium urate, 46. Di-potassium urate, 46. Murexide test for uric acid, 46. Reduction of silver nitrate by uric acid, 46. Murexide test for caffeine, 46.	
XXIII. BENZENE AND ITS HOMOLOGUES (263-270) .....	47
Stability of benzene towards the halogens, 47. Absence of double bonds in benzene, 47. Nitrobenzene, 47. Benzenemonosulphonic acid, 47. FRIEDEL and CRAFTS' reaction, 47. Formation of benzene from calcium benzoate, 47. Oxidation of side-chains, 48.	
XXIV. MONOHALOGEN COMPOUNDS (272 and 273) .....	48
Stability of monochlorobenzene towards alcoholic potash or soda, 48. Saponification of benzyl chloride by caustic potash or soda, 48. Benzyl iodide, 48.	
XXV. MONOHYDRIC PHENOLS (274-276) .....	49
Preparation of phenol from calcium salicylate, 49. Preparation of phenol by fusion of sodium benzenesulphonate with caustic soda, 49. Sodium phenoxide, 49. Tribromophenol, 49. Ferric-chloride test for phenol, 49. Depression of the freezing-point of phenol, 49. Action of nitric acid on phenol, 50. Cresol, 50.	
XXVI. MONOAMINO-COMPOUNDS AND THEIR DERIVATIVES (282-291) ..	50
Aniline, 50. Neutral reaction of aniline, 50. Aniline salts, 51. Tribromoaniline, 51. Bleaching-powder test for aniline, 51. Potassium-dichromate test for aniline, 51. Acetanilide, 51. Carbylamine reaction, 51. Diphenylamine, 51. Nitrosodimethylaniline, 51. Azobenzene, hydrazobenzene, and benzidine sulphate, 52. Diphenylurea, 52.	
XXVII. BENZOIC ACID AND ITS DERIVATIVES (296-298) .....	52

Benzenediazonium chloride, 55. Replacement of the $N_2$ -group in benzenediazonium chloride by hydroxyl, 55. Diazoaminobenzene, 56. Aminoazobenzene, 56. Dyeing with aminoazobenzene, 56. Reduction of aminoazobenzene, 56. Oxidation of phenylhydrazine by FEHLING's solution, 56.	
XXX. POLY-SUBSTITUTED DERIVATIVES CONTAINING SIMILAR SUBSTITUENTS (310-331) .....	57
Pyrogallol, 57. Benzoquinone, 57. Tests for catechol, resorcinol, and quinol, 57. <i>m</i> -Dinitrobenzene, 57. Test for nitrous acid with <i>m</i> -phenylenediamine, 58. Phthalic anhydride, 58. Fluorescein, 58. Phenolphthalein, 58. Red anion of phenolphthalein, 58.	
XXXI. POLY-SUBSTITUTED DERIVATIVES CONTAINING TWO OR MORE DISSIMILAR SUBSTITUENTS (332-351) .....	59
<i>p</i> -Diazobenzenesulphonic acid, 59. Nitrophenols, 59. Picric acid, 59. Potassium picrate, 59. Taste of picric acid, 59. Dyeing with picric acid, 60. Isopurpuric acid, 60. Chloropicrin, 60. Ionization of picric acid in aqueous solution, 60. Salicylic acid, 60. Action of bromine-water on salicylic acid, 60. Identification of salicylic acid and phenol, 60. Calcium salicylate, 60. Action of tannin on gelatine, 60. Test for tannin, 60. Action of tannin on quinine, 61. Interaction of albumin and tannin, 61. Hydrolysis of <i>p</i> -nitraniline hydrochloride, 61.	
XXXII. TERPENES AND CAMPHORS (358-363) .....	61
Artificial camphor, 61. Volatility of camphor with steam, 61. Camphor and water, 62. Camphoric acid, 62.	
XXXIII. BENZENE-NUCLEI LINKED TOGETHER BY CARBON (364-369) .....	62
Rosolic acid, 62. Magenta, 62. Action of concentrated hydrochloric acid on a solution of magenta, 62. Colour-base, 62. Leuco-base, 63.	
XXXIV. CONDENSED BENZENE-NUCLEI (370-385) .....	63
Action of heat on naphthalene, 63. Naphthalene picrate, 63. Naphthalenemonosulphonic acid, 63. $\alpha$ -Nitronaphthalene, 63. Crude naphthol, 63. Martius' yellow, 63. Naphthylamines, 64. Congo-red, 64. Naphthionic acid, 64. Oxidation of anthracene by chromic acid, 64. Test for anthraquinone, 64. Alizarin, 64.	

	PAGE
XXXV. HETEROCYCLIC COMPOUNDS (386-394) .....	65
Pyridine, 65. Action of pyridine on ferric chloride, 65.	
Test for pyridine, 65. Action of the alkaloid-reagents	
on pyridine, 65. Stability of pyridine towards von	
BAEYER's reagent, 65. Stability of pyridine towards	
oxidizing-agents, 65. Pyrrole-red, 65. Indophenin	
reaction, 66. Tests for antipyrine, 66.	
XXXVI. CONDENSATION-PRODUCTS OF BENZENE AND HETEROCYCLIC	
NUCLEI (395-399) .....	66
SKRAUP's synthesis of quinoline, 66. Quinoline hydro-	
chloride, 66. Quinoline picrate, 66. Quinoline di-	
chromate, 67. Volatility of indigo, 67. Solubility of	
indigo in nitrobenzene, 67. Indigosulphonic acid, 67.	
Oxidation of indigo to isatin, 67. "Indigo-vatting," 67.	
XXXVII. ALKALOIDS (400-411) .....	67
Alkaloid-reagents, 67. Nicotine, 67. Fluorescence of	
quinine-sulphate solution, 68. Action of chlorine on	
quinine salts, 68. Test for strychnine, 68. Test for	
brucine, 68.	
XXXVIII. ALBUMINS (412-418) .....	68
Detection of nitrogen and sulphur in the albumins, 68.	
"Salting-out" albumin with ammonium sulphate, 68.	
Coagulation of albumin by alcohol, 69. Coagulation	
of albumin by nitric acid, 69. Biuret reaction, 69.	
MILLON's reagent, 69. Xanthoprotein reaction, 69.	
ADAMKIEWICZ's reaction, 69. Decomposition-products	
of ceratin, 69.	

# A LABORATORY MANUAL OF ORGANIC CHEMISTRY.

---

## I. QUALITATIVE ANALYSIS OF CARBON COMPOUNDS.

(3-8.)

### DETECTION OF CARBON AND HYDROGEN (3).

1. **Carbonization.**—A small quantity of sugar is heated in a crucible covered with a lid. Inflammable gases are evolved, leaving a residue of charcoal. This is proved to be carbon by heating it in a hard-glass tube about 15 cm. long sealed at one end, and slightly inclined, the tube being first filled with oxygen, and closed with a loosely-fitting cork. Carbon dioxide is formed, part remaining in the tube. After cooling, lime-water is agitated with the gas, and becomes turbid owing to the formation of calcium carbonate,  $\text{CaCO}_3$ .

The presence of carbon in coal-gas is shown by the soot deposited when a cold surface, such as that of a porcelain crucible-lid, is introduced into a luminous flame.

2. **Oxidation with Copper Oxide.**—10 g. of finely-powdered copper oxide—a hygroscopic substance—are dried by heating in a dish or crucible. While still warm it is mixed carefully with a *small* quantity of sugar, and the mixture placed in a hard-glass tube sealed at one end; the open end of the tube is then closed with a cork, and a delivery-tube leading into lime-water. On heating, the sugar is oxidized by the copper oxide;

	PAGE
XXXV. HETEROCYCLIC COMPOUNDS (386-394) .....	65
Pyridine, 65. Action of pyridine on ferric chloride, 65.	
Test for pyridine, 65. Action of the alkaloid-reagents on pyridine, 65. Stability of pyridine towards VON BAEYER'S reagent, 65. Stability of pyridine towards oxidizing-agents, 65. Pyrrole-red, 65. Indophenin reaction, 66. Tests for antipyrine, 66.	
XXXVI. CONDENSATION-PRODUCTS OF BENZENE AND HETEROCYCLIC NUCLEI (395-399) .....	66
SKRAUP'S synthesis of quinoline, 66. Quinoline hydrochloride, 66. Quinoline picrate, 66. Quinoline dichromate, 67. Volatility of indigo, 67. Solubility of indigo in nitrobenzene, 67. Indigosulphonic acid, 67. Oxidation of indigo to isatin, 67. "Indigo-vatting," 67.	
XXXVII. ALKALOIDS (400-411) .....	67
Alkaloid-reagents, 67. Nicotine, 67. Fluorescence of quinine-sulphate solution, 68. Action of chlorine on quinine salts, 68. Test for strychnine, 68. Test for brucine, 68.	
XXXVIII. ALBUMINS (412-418) .....	68
Detection of nitrogen and sulphur in the albumins, 68.	
"Salting-out" albumin with ammonium sulphate, 68.	
Coagulation of albumin by alcohol, 69. Coagulation of albumin by nitric acid, 69. Biuret reaction, 69.	
MILLON'S reagent, 69. Xanthoprotein reaction, 69.	
ADAMKIEWICZ'S reaction, 69. Decomposition-products of ceratin, 69.	

# A LABORATORY MANUAL OF ORGANIC CHEMISTRY.

---

## I. QUALITATIVE ANALYSIS OF CARBON COMPOUNDS.

(3-8.)

### DETECTION OF CARBON AND HYDROGEN (3).

**1. Carbonization.**—A small quantity of sugar is heated in a crucible covered with a lid. Inflammable gases are evolved, leaving a residue of charcoal. This is proved to be carbon by heating it in a hard-glass tube about 15 cm. long sealed at one end, and slightly inclined, the tube being first filled with oxygen, and closed with a loosely-fitting cork. Carbon dioxide is formed, part remaining in the tube. After cooling, lime-water is agitated with the gas, and becomes turbid owing to the formation of calcium carbonate,  $\text{CaCO}_3$ .

The presence of carbon in coal-gas is shown by the soot deposited when a cold surface, such as that of a porcelain crucible-lid, is introduced into a luminous flame.

**2. Oxidation with Copper Oxide.**—10 g. of finely-powdered copper oxide—a hygroscopic substance—are dried by heating in a dish or crucible. While still warm it is mixed carefully with a *small* quantity of sugar, and the mixture placed in a hard-glass tube sealed at one end; the open end of the tube is then closed with a cork, and a delivery-tube leading into lime-water. On heating, the sugar is oxidized by the copper oxide;

or by addition of two or three drops of a solution of sodium nitroprusside to the alkaline mixture, when a deep-violet colouration results, some minutes elapsing before the colour attains its maximum intensity. Traces of sulphur can be detected by this reaction.

## II. THE ALLOTROPIC MODIFICATIONS OF CARBON.

(16.)

1. **Graphite.**—0.1 g. of graphite is mixed with 5 g. of finely powdered copper oxide, and heated to a high temperature in the apparatus described in I, 2. The evolved carbon dioxide renders the lime-water turbid.

2. **Wood-charcoal.**—A piece of wood-charcoal is gently heated in a test-tube; the water occluded in the pores of the charcoal evaporates, and condenses in drops on the cool parts of the tube.

A piece of wood-charcoal is placed in water, and the mixture warmed. The air present in the pores of the charcoal escapes, forming bubbles in the water.

3. **Bone-charcoal.**—Pieces of bone are placed in a crucible fitted with a lid, and heated in a fume-cupboard. Vapours of disagreeable odour are evolved, the residue in the crucible consisting of bone-charcoal and the mineral constituents of the bones. The bone-ash is freed from these by heating the mixture with hydrochloric acid.

4. **Decolourization of Solutions by Bone-charcoal.**—20 c.c. of a very dilute solution of magenta—a red dye—are agitated with a teaspoonful of bone-charcoal, and filtered. The filtrate is colourless (*"Inorganic Chemistry,"* 177).

5. **Absorption of Lead Salts by Bone-charcoal.**—20 c.c. of a very dilute solution of lead acetate are tested for lead by addition of an aqueous solution of sulphuretted hydrogen. The solution must be so dilute that it gives a brown turbidity, but no precipitate.

A like volume of the lead-acetate solution is agitated for a short time with a teaspoonful of bone-charcoal, and then filtered. On addition of sulphuretted-hydrogen water, no turbidity or brown colouration is developed in the filtrate ("Inorganic Chemistry," 177).

**6. Deodourizing Action of Bone-charcoal.**—A dilute aqueous solution of sulphuretted hydrogen, having a perceptible odour of the gas, is agitated with bone-charcoal, and filtered. An odourless filtrate is obtained.

### III. LABORATORY METHODS.

(18-27.)

**1. Fractional Distillation.**—50 c.c. of rectified spirit are placed in a 100-c.c. fractionating-flask fitted with a thermometer and connected with a condenser, and gently heated with a small flame. The liquid begins to boil about  $78^{\circ}$ , and the distillate is collected in two fractions, the first passing over below  $88^{\circ}$ , and the second above that temperature. After the distillation is complete, the first fraction is returned to the flask, and slowly distilled till the thermometer again reaches  $88^{\circ}$ . The burner is then removed, the second fraction poured back into the flask, and the distillation continued without changing the receiver till the temperature has again risen to  $88^{\circ}$ . A different receiver is now employed, and the process continued till distillation is complete.

The first fraction contains most of the alcohol, and can be ignited; the second is chiefly water, and is incombustible.

**2. Steam Distillation.**—100 c.c. of petroleum are placed in a 200-c.c. flask *d* (Fig. 1) connected with a condenser. Water is boiled in the can *a*, which is fitted with a safety-tube *b* and a delivery-tube *c*, the evolved steam being passed into the flask *d* through a glass tube reaching to the bottom, and bent as in the illustration. The flask is inclined at an angle to prevent the



petroleum being carried over mechanically. The distillate is a mixture of petroleum and water.

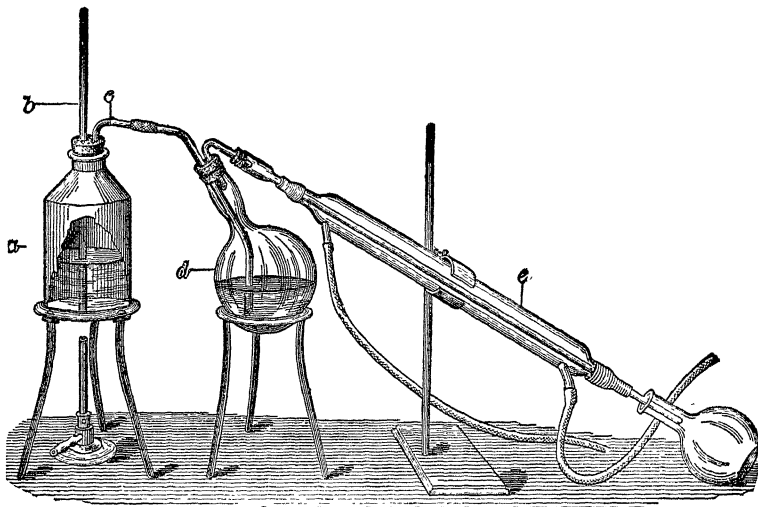


FIG. 1.—Steam Distillation.

**3. Extraction with Solvents.**—10 c.c. of a five per cent. solution of urea and 10 c.c. of ether are introduced into a separating-funnel, and the mixture vigorously shaken. When the liquid has separated into two layers, these are removed, and each is evaporated to dryness in a porcelain dish on the water-bath. Only a trace of urea is obtained from the ether, this substance being very soluble in water, and almost insoluble in ether.

A saturated solution of salicylic acid is prepared by vigorously agitating 1 g. of the acid with 25 c.c. of water, and filtering. The filtrate is extracted with 10 c.c. of ether as described in the last paragraph. Almost all the salicylic acid dissolves in the ether, being very soluble in this solvent, and but slightly soluble in water.

**4. Determination of the Melting-point.**—A little naphthalene is placed in a narrow glass tube sealed at one end, several

of these being obtained by drawing out a test-tube. The capillary tube is fastened with an india-rubber ring to the stem of a thermometer, so that the part containing the naphthalene is about half-way up the mercury bulb. The end of the thermometer carrying the tube is then immersed in a beaker of water, which is slowly heated with a small flame. When the substance melts, the temperature ( $80^{\circ}$ ) of the thermometer is observed.

**5. Determination of the Boiling-point.**—A small quantity of benzene is placed in a fractionating-flask having a high side-tube connected with a condenser. The flask is closed with a cork fitted with a thermometer whose bulb is placed several centimetres below the side-tube. The benzene is heated with a small flame to ebullition, and the temperature at which the mercury becomes stationary noted. This is the boiling-point.

**6. Crystallization.**—3 g. of crude oxalic acid are dissolved in 10 c.c. of hot water, and the impurities present in the acid removed by filtering the turbid solution. On standing, the clear filtrate deposits crystals of oxalic acid. The mother-liquor is poured off, the crystals are drained on a funnel, and dried on a porous plate or between sheets of filter-paper.

#### IV. SATURATED HYDROCARBONS.

(29–42.)

**1. Preparation of Methane,  $\text{CH}_4$ .**—One part by weight of sodium acetate, which has been fused and finely powdered, is thoroughly mixed with four parts by weight of soda-lime. The mixture is heated in a hard-glass retort of 100 c.c. capacity, fitted with a delivery-tube for collecting the gas in cylinders over water. Methane thus prepared always contains some hydrogen, and to obtain a product of maximum purity, it is best to keep the temperature as low as possible. A thick-walled cylinder is filled with methane, closed with a glass plate,

and turned mouth upwards. On removal of the cover, and ignition of the gas with a burner or taper, it burns with a flame of feeble luminosity. When combustion ceases, some lime-water is poured quickly into the cylinder, the cover replaced, and the contents agitated. The carbon dioxide formed by the combustion of the gas renders the lime-water turbid.

A thick-walled explosion-cylinder is filled about one-third full with methane, and the remainder with oxygen. On ignition, the mixture explodes with a loud report.

A cylinder is filled with chlorine by downward displacement, and over it is placed an inverted cylinder full of methane, closed with a glass plate. The plate is removed, and the gases mixed by inverting the cylinders several times, care being taken to prevent loss. After insertion of two glass plates between the cylinders, one is placed mouth downwards in a saturated solution of common salt, and the cover removed. In *diffused* daylight the liquid slowly rises, the colour of the chlorine disappears, and oily drops of the substitution-products—methylene chloride,  $\text{CH}_2\text{Cl}_2$ ; chloroform,  $\text{CHCl}_3$ ; and carbon tetrachloride,  $\text{CCl}_4$ —are deposited on the sides of the cylinder. The mixture must not be exposed to *direct* sunlight, or there is danger of an explosion. On ignition of the contents of the other cylinder, hydrochloric acid is produced, and soot deposited.

**2. Distillation of Petroleum.**—Petroleum is distilled slowly from a flask connected with a condenser and fitted with a thermometer. The boiling-point rises gradually, proving the liquid to be a mixture.

**3. Inflammability of Petroleum-vapour.**—5 c.c. of petroleum are poured into a porcelain dish. A lighted match plunged into the liquid is extinguished. If, however, the petroleum is carefully heated to  $40^\circ$  on a water-bath, the inflammable vapour evolved is ignited by the application of a burning match.

**4. Stability of the Saturated Hydrocarbons.**—Samples of petroleum and of paraffin-wax are agitated with concentrated sulphuric acid and with concentrated nitric acid. Being mix-

tures of saturated hydrocarbons, they are neither acted on nor dissolved.

## V. ALCOHOLS, $C_nH_{2n+1}\cdot OH$ .

(43-55.)

1. **Action of Sodium upon Alcohol.**—0.5 g. of sodium is introduced into a small fractionating-flask containing 10 c.c. of absolute alcohol, and fitted with a delivery-tube for collecting gas over water. The mouth of the flask is immediately closed with a cork, and an energetic evolution of gas takes place. The gas is collected in a cylinder, and proved by ignition to be hydrogen.

2. **Fusel-oil.**—A small quantity of crude spirit is evaporated slowly on a water-bath. After the volatilization of the ethyl alcohol, the odour of fusel-oil is very marked. It is also perceptible when a few drops of the spirit are placed on the palm of the hand, and rubbed with the finger to promote the evaporation of the ethyl alcohol.

3. **Wine.**—25 c.c. of wine contained in a fractionating flask connected with a condenser are heated on a water-bath. Alcohol distils and can be recognized by its odour and inflammability.

4. **Heat Developed by Mixing Alcohol and Water.**—10 c.c. of absolute alcohol and 10 c.c. of water are poured into two small beakers, and these immersed in a large vessel of water to bring them to the same temperature. This is noted, and after removal of the beakers from the water their contents are mixed quickly and stirred with the thermometer. A rise in temperature is observed.

5. **Test for Water in Alcohol.**—3 g. of blue, crystallized copper sulphate  $CuSO_4 + 5H_2O$  are gently heated in a porcelain crucible till anhydrous the salt being converted into a white powder. When cold, the residue is transferred to a test-tube or small

flask containing 15 c.c. of aqueous alcohol; the copper sulphate soon regains its original blue colour, on account of the formation of the hydrated salt,  $\text{CuSO}_4 + 5\text{H}_2\text{O}$ .

**6. Separation of Water from Alcohol.**—Rectified spirit is agitated with solid potassium carbonate, and, if enough of the salt has been added, two layers are obtained. These are separated by means of a tap-funnel. The upper layer is strong alcohol, and burns on ignition; the lower layer is a concentrated, aqueous solution of potassium carbonate, containing only a trace of alcohol.

**7. Oxidation of Ethyl Alcohol.**—Ethyl alcohol is heated with an aqueous solution of potassium permanganate until the violet colour has disappeared and manganese dioxide has been precipitated. On acidifying the mixture with sulphuric acid and distilling, an acid distillate with an odour of acetic acid is obtained.

## VI. ALKYL HALIDES, ESTERS, AND ETHERS.

(56-64.)

**1. Ethyl Chloride.**—A mixture of 10 c.c. of alcohol and 5 c.c. of concentrated sulphuric acid is added to 5 g. of common salt contained in a 50-c.c. fractionating-flask connected with a condenser in a fume-cupboard. On warming, gaseous ethyl chloride,  $\text{C}_2\text{H}_5\text{Cl}$ , is evolved, and dissolves in the condensed alcohol. When ignited, this distillate burns with a green flame—a phenomenon characteristic of many chlorine derivatives. The presence of chlorine can also be proved by BEILSTEIN'S test (I, 4a).

**2. Ethylsulphuric Acid.**—About 2 c.c. of concentrated sulphuric acid are poured carefully into an equal volume of absolute alcohol, the mixing being accompanied by rise of temperature. The mixture is heated gently for a short time, cooled, and poured into 25 c.c. of water. This solution is stirred, and barium carbonate added till the liquid is no longer acid to litmus. Carbon dioxide is evolved, with formation of insoluble barium sulphate

and soluble barium ethylsulphate,  $\text{Ba}(\text{C}_2\text{H}_5\text{SO}_4)_2$ . After filtering, dilute sulphuric acid is added to a portion of the filtrate; the precipitate of barium sulphate formed proves the presence of a barium salt in solution.

On warming the rest of the filtrate with dilute hydrochloric acid, barium sulphate is precipitated. This is due to the decomposition of the liberated ethylsulphuric acid into alcohol and sulphuric acid, followed by the interaction of the latter with the barium ions present in the solution.

**3. Diethyl Ether,  $(\text{C}_2\text{H}_5)_2\text{O}$ .**—A fractionating-flask is fitted with a cork carrying a tap-funnel and a thermometer, both arranged to nearly touch the bottom. After 50 c.c. of alcohol of ninety per cent. strength and 50 c.c. of concentrated sulphuric acid have been poured into the flask, it is connected with a condenser through whose jacket a rapid current of water is flowing. Heat is then applied till the thermometer indicates a temperature between  $130^\circ$  and  $140^\circ$ . As soon as the distillation of ether begins, alcohol is introduced slowly into the flask from the tap-funnel, and the distillation continued with a small flame so as to maintain the temperature constant. The distillate is agitated in a separating-funnel with a like volume of water, which dissolves most of the alcohol, leaving a layer of ether floating on the surface of the solution. After separation from the latter, the ether is dried by agitation for a few minutes with fused and finely-powdered calcium chloride.

A small quantity of the ether is agitated with a large excess of water, in which it dissolves.

A mixture of 5 c.c. of ether and 5 c.c. of water is shaken in a separating-funnel, and the ethereal and aqueous layers separated carefully. Anhydrous copper sulphate added to this ether turns blue, proving that the ether has dissolved some of the water. On gently warming the aqueous layer in a porcelain dish, ether-vapour is evolved, and can be recognized by its odour and inflammability. This proves that the water has dissolved some of the ether.

A few drops of ether are poured into a porcelain dish and ignited, a very luminous flame being obtained.

The absorption of heat caused by the evaporation of ether can be demonstrated by placing a small quantity in the palm of the hand, and blowing on it. A sensation of cold is felt immediately.

**4. Ethylmercaptan.**—On warming 2 c.c. of a saturated solution of potassium ethylsulphate with a like volume of a thirty-three per cent. solution of potassium hydrogen sulphide, KHS, the odour of ethylmercaptan at once becomes perceptible (66).

## VII. AMINES AND NITRO-COMPOUNDS.

(69-77.)

### AMINES (69-74).

**1. Methylamine.**—A thin paste of bleaching-powder is rendered strongly alkaline by addition of slaked lime, and mixed with an aqueous solution of 1 g. of acetamide,  $\text{CH}_3\cdot\text{CONH}_2$ . On distillation, an aqueous solution of methylamine,  $\text{CH}_3\cdot\text{NH}_2$ , is obtained (244).

**2. Carbylamine Reaction.**—A portion of the solution thus obtained is warmed gently with one or two drops of chloroform and a small quantity of alcoholic potash. Owing to the formation of methylcarbylamine,  $\text{CH}_3\cdot\text{NC}$ , the odour characteristic of isonitriles is perceived (84).

**3. Mustard-oil Reaction.**—A mixture of carbon disulphide and absolute alcohol in like proportions is added to another portion of the distillate obtained in 1, till solution is complete, and the liquid is warmed for a short time. On addition of ferric chloride, a black precipitate of sulphide of iron is formed; and, on further heating, the odour of methyl-mustard-oil,  $\text{CH}_3\cdot\text{NCS}$ , becomes perceptible (254).

**4. Reaction with Copper Salts.**—The remainder of the distillate of 1 is added drop by drop to a dilute solution of copper

sulphate. At first a precipitate of copper hydroxide is formed, and, on further addition of the amine-solution, this redissolves, with production of a deep-blue colour. The reaction, therefore, is analogous to that between ammonium hydroxide and copper salts ("Inorganic Chemistry," 244).

**5. Nitrous-acid Test.**—A concentrated aqueous solution of 1 g. of ethylamine hydrochloride,  $C_2H_5NH_2 \cdot HCl$ , and 1 g. of potassium or sodium nitrite is poured slowly through a thistle-funnel into a 50-c.c. fractionating-flask *a*, containing 20 c.c. of glacial acetic acid (Fig. 2). The evolved nitrogen is freed from

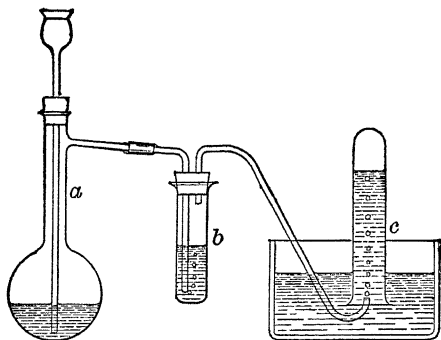


FIG. 2.—Nitrous-acid Test for Primary Amines.

traces of ethyl nitrite by passing it through a small wash-bottle *b*, containing alcoholic potash. The gas is collected over water in a cylinder *c*, and proved to be nitrogen by its extinguishing a lighted wood-splint or taper. By means of the iodoform test (XIII, 5), the presence of alcohol in the fractionating-flask can be shown.

**6. Nitrosamines.**—To a cold, saturated, aqueous solution of 1 g. of potassium or sodium nitrite is added 1 g. of solid diethylamine hydrochloride,  $(C_2H_5)_2NH \cdot HCl$ , and one drop of dilute sulphuric acid. On gently heating the liquid, diethylnitrosamine,  $(C_2H_5)_2N \cdot NO$ , collects on the surface as a yellow oil of characteristic odour (72).



**7. Dimethylamine and Trimethylamine.**—A small quantity of caustic-soda solution is added to herring-brine contained in a distilling-flask connected with a condenser. On heating, a distillate is obtained; this is alkaline, owing to the presence of dimethylamine and trimethylamine. Like ammonium hydroxide, it precipitates ferric hydroxide,  $\text{Fe}_2\text{O}_3 + n\text{H}_2\text{O}$ , from a solution of ferric chloride.

### NITRO-COMPOUNDS (75-77).

**1. Sodium Nitromethane.**—A solution of 3 drops of nitromethane in 1 c.c. of absolute alcohol is prepared. To this are added a few drops of a solution of sodium ethoxide, obtained by dissolving small pieces of sodium in 10 c.c. of absolute alcohol. The white precipitate of sodium nitromethane is filtered off, and, while still moist, is dissolved in a small quantity of water. *It must not be dried or a dangerous explosion may result.* When moist, it is innocuous.

**2. Nitrolic-acid Reaction.**—The liquid thus obtained is agitated with a few drops of a concentrated aqueous solution of sodium nitrite, and carefully acidified with dilute sulphuric acid. On addition of dilute caustic-soda solution, a blood-red solution of the sodium salt of methylnitrolic acid is produced.

**3. Reduction of Nitro-compounds.**—To caustic potash and granulated zinc contained in a test-tube are added 3 drops of nitromethane. The characteristic odour of methylamine at once becomes perceptible, and a strip of red litmus-paper held in the vapour is turned blue.

## VIII. NITRILES AND ISONITRILES.

(83-85.)

**1. Preparation.**—A mixture of 10 g. of potassium ethylsulphate and 10 g. of dried potassium ferrocyanide is submitted to dry distillation in a retort connected with a condenser. The

distillate has the isonitrile odour, due to the presence of ethyl-carbylamine. Agitation with dilute sulphuric acid for a short time removes this smell, whereupon that of the nitrile—propionitrile—formed in the reaction becomes perceptible, although it was previously wholly masked by that of the isonitrile, a by-product.

**2. Hydrolysis of Nitriles.**—The liquid of 1 is made alkaline with caustic potash, and boiled in a test-tube. The evolution of alkaline vapours can be detected by means of a strip of moistened, red litmus-paper.

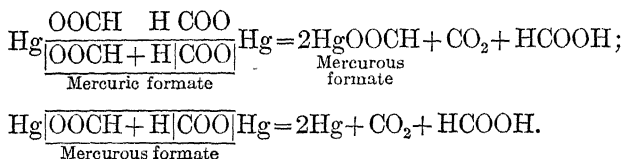
The reaction-mixture contains potassium propionate. On acidifying with dilute sulphuric acid and distilling, propionic acid passes over, the distillate turning blue litmus red.

## IX. SATURATED ACIDS, $C_nH_{2n}O_2$ ; AND ESTERS.

(86-92; 97.)

**1. Formic Acid.**—A mixture of 10 g. of glycerol and 10 g. of crystallized oxalic acid is heated in a fractionating-flask connected with a condenser. Carbon dioxide is evolved, as can be demonstrated by holding a test-tube containing lime-water at the outlet of the condenser so that the gas enters the tube. After an energetic evolution of gas has continued for some time, 5 g. of crystallized oxalic acid are added, and the heating renewed. Formic acid distils (158).

**2. Decomposition of Mercuric Formate.**—A portion of the distillate of 1 is agitated with a small quantity of finely-divided mercuric oxide, prepared by triturating the powder in a mortar with a little water. The resulting solution of mercuric formate is filtered from the excess of mercuric oxide, and heated. At first, carbon dioxide is evolved, and white mercurous formate precipitated. On further heating, the mercurous salt is decomposed with evolution of carbon dioxide, and precipitation of metallic mercury:



The liquid now contains free formic acid, and, therefore, turns blue litmus red. It is filtered, and the filtrate is neutralized exactly with caustic soda or ammonium hydroxide; on addition of silver-nitrate solution, silver formate is precipitated. When this is heated, it decomposes with evolution of carbon dioxide, liberating half the formic acid and precipitating metallic silver, analogously to the mercury salt. The reaction of the liquid, therefore, again becomes acid.

### 3. Action of Concentrated Sulphuric Acid on Formic Acid.—

Another portion of the distillate of 1 is placed in a small flask, and kept cool during the slow addition of twice its volume of sulphuric acid. The flask is closed with a cork and delivery-tube, the end of the latter dipping under water in a pneumatic trough. On the application of heat, a gas is evolved. This is collected in a cylinder, and, on ignition, burns with the blue flame characteristic of carbon monoxide. Agitation of the contents of the cylinder with lime-water produces turbidity proving the formation of carbon dioxide by the combustion.

### 4. Oxidation of Formic Acid by Potassium Permanganate.—

The remainder of the formic acid obtained in 1 is heated with a small quantity of potassium permanganate and dilute sulphuric acid in the apparatus employed in 3, the end of the delivery-tube being immersed in lime-water contained in a test-tube. The permanganate solution is decolourized, and the carbon dioxide produced by the oxidation of the formic acid renders the lime-water turbid.

**5. Cacodyl Test for Acetic Acid.**—On distilling sour beer (200 c.c.), an acid distillate is obtained with an odour of acetic acid. The distillate is nearly neutralized with a few drops of

caustic-soda solution, a slightly acid reaction being maintained. It is then evaporated, the last traces of water being removed by heating over a free flame. A portion of the anhydrous sodium acetate thus obtained is mixed with arsenious oxide, and the mixture heated gently in a test-tube. The excessively disagreeable odour of cacodyl oxide,  $(\text{CH}_3)_2\text{As}-\text{O}-\text{As}(\text{CH}_3)_2$ , is soon perceived (80). *This substance being extremely poisonous, great care must be exercised in carrying out the experiment, and the heating should be discontinued as soon as the odour has been detected.*

**6. Stability of Acetic Acid towards Oxidizing-agents.**—To 5 drops of acetic acid are added small quantities of dilute potassium-permanganate solution and dilute sulphuric acid. Unlike formic acid, the acetic acid does not decolourize the permanganate solution.

**7. Silver Acetate.**—1 g. of sodium acetate is dissolved in 10 c.c. of water, and a solution of silver nitrate added. The precipitate of silver acetate, which is only slightly soluble in water at the ordinary temperature, is collected on a filter, and sufficient to saturate the aqueous solution at the boiling-point transferred to a beaker containing 50 c.c. of boiling, distilled water. On cooling, the salt crystallizes in long, silky needles. These are filtered off, spread on a porous plate to remove as much of the mother-liquor as possible, and dried in a dish on the water-bath. On carefully heating the salt in a porcelain crucible, it decomposes, leaving a residue of metallic silver.

**8. Test for Acetic Acid.**—A few drops of ferric chloride are added to a *dilute* solution of sodium acetate. Owing to the formation of ferric acetate, the liquid turns blood-red. On boiling this solution, a reddish-brown, flocculent precipitate of basic acetate of iron is formed. If allowed to stand for a short time, this sinks to the bottom of the test-tube, leaving the supernatant liquid colourless.

**9. Oxidation of Ethyl Alcohol to Acetic Acid.**—A mixture of 6 g. of potassium dichromate and 10 g. of concentrated sulphuric

acid is introduced into a 100-c.c. distilling-flask connected with a condenser, and a solution of 2 c.c. of alcohol in 10 c.c. of water added drop by drop from a tap-funnel. On heating, acetic acid distils, and can be recognized by its odour, or, after careful neutralization with sodium carbonate, by the ferric-chloride test (8).

**10. Saponification of Butter.**—About 5 g. of butter are saponified by boiling in a porcelain dish with 20 c.c. of a solution of 1 part of caustic soda in 2 parts of water, the mixture being constantly stirred. After a few minutes, it begins to foam. The heating is continued for twenty minutes, and the contents of the dish allowed to cool. The liquid separates into two layers—the lower an aqueous solution of glycerol and caustic soda, and the upper the fused sodium salts of the fatty acids, which are insoluble in concentrated caustic-soda solution. When cold, the upper layer is semi-solid. It is separated from the aqueous solution, and dissolved in water to separate it from unsaponified fat. This can be almost completely removed by filtration through a moistened filter-paper.

**11. Calcium and Lead Salts of the Higher Fatty Acids.**—A part of the soap solution obtained by the method described in 10 is neutralized with dilute acetic acid, and calcium chloride and lead acetate respectively added to separate portions. Precipitates of the calcium and lead salts of the higher fatty acids are formed.

**12. Volatile Fatty Acids.**—The rest of the soap solution is poured into a 100-c.c. distilling-flask connected with a condenser, and excess of dilute sulphuric acid added. On heating, water and the *volatile fatty acids* of the butter distil, chief of the latter being *n*-butyric acid. They can be detected by their odour and acid reaction.

**13. Higher Fatty Acids.**—After the distillation of the volatile fatty acids, the residue in the flask consists of the solid *higher fatty acids*. It is transferred to a porcelain dish, allowed to cool, and the solid layer of fatty acids triturated with

water several times to remove adhering sulphuric acid. To prove that the mixture has an acid reaction, it is dissolved in alcohol, and the solution added drop by drop to a very dilute solution of caustic soda, coloured red by a drop of phenolphthaleïn. The colour disappears, and the acids dissolve, proving that the alkali has been neutralized.

**14. Soap.**—A few drops of an alcoholic solution of phenolphthaleïn are added to a concentrated, neutral soap solution. On dilution with a large excess of water, the colourless liquid becomes red, owing to the liberation of free alkali by the hydrolytic dissociation of the salts of the fatty acids (92).

A solution of calcium sulphate is added to one of soap, whereupon the calcium salts of the higher fatty acids are precipitated.

**15. Ethyl Acetate.**—Dry hydrochloric-acid gas is passed into a mixture of 10 c.c. of glacial acetic acid and 15 c.c. of absolute alcohol. The gas can be prepared by gently heating dried common salt with concentrated sulphuric acid in a flask, or can be obtained from a Kipp generator charged with fused ammonium chloride and concentrated sulphuric acid. The mixture is heated for an hour under a reflux-condenser, and then poured into water. Drops of ethyl acetate separate, a liquid characterized by its pleasant and refreshing odour.

**16. Velocity of Saponification of Ethyl Acetate.**—A small quantity of ethyl acetate is dissolved in water, and like volumes of the solution transferred to two test-tubes fitted with corks. One portion is agitated with a few drops of caustic potash or soda, and the other with a like volume of dilute sulphuric acid. Since the saponification is effected much more rapidly by the caustic alkali than by the acid, the odour of the ester vanishes from the first tube much sooner than from the second.

**17. Solubility of Ethyl Acetate in Water.**—An excess of ethyl acetate is vigorously agitated with 25 c.c. of water at the ordinary temperature till saturation is complete, and the

aqueous solution is separated from the undissolved ester. When warmed, the solution becomes turbid from the separation of ethyl acetate, which is more soluble in cold than in hot water.

## X. ALDEHYDES AND KETONES.

(106-121.)

### ALDEHYDES (106-118).

**1. Acetaldehyde.**—A mixture of 60 g. of water, 20 g. of concentrated sulphuric acid, and 15 g. of ninety per cent. alcohol is added to 13 g. of potassium dichromate contained in a 200-c.c. fractionating-flask connected with a condenser. Sometimes the oxidation begins spontaneously; should it not, however, the flask is gently heated on a sand-bath, with a rapid current of cold water flowing through the condenser. A mixture of water, alcohol, acetaldehyde, and acetal distils, and can be used in carrying out the aldehyde-reactions described in 2, 3, and 4.

**2. Silver-mirror Test.**—A small portion of the distillate is diluted with water in a *clean* test-tube, and a few drops of an ammoniacal silver solution added. This is prepared by adding a small excess of a solution of caustic soda to one of silver nitrate and then ammonium hydroxide drop by drop in sufficient quantity to just redissolve the precipitate. After being shaken the test-tube is immersed in water heated almost to its boiling point. If the tube is thoroughly clean, the reduced silver is deposited on its sides as a mirror; if not, a black precipitate of the metal is obtained.

**3. Aldehyde-resin.**—Caustic potash is added to another portion of the distillate, and the mixture warmed. A yellow colouration is produced at once, and, on further heating, a precipitate of aldehyde-resin is formed.

4. **SCHIFF's Reaction.**—Another portion of the distillate is added to a solution of magenta decolourized with sulphurous acid—SCHIFF's *reagent*. The red colour of the dye is restored.

5. a) **Action of Formalin on Egg-albumin.**—To 10 c.c. of a forty per cent. solution of formaldehyde—the “formalin” of commerce—is added 1 c.c. of the albumin of a hen's egg. Coagulation at once takes place.

b) **Action of Formaldehyde on Gelatine.**—To a solution of 3 g. of gelatine in 100 c.c. of water are added 2 c.c. of “formalin.” An insoluble compound of gelatine and formaldehyde is soon produced, causing coagulation of the liquid.

#### KETONES (106–112, 119 and 120).

6. **Acetone.**—About 50 g. of dried calcium acetate are heated to a high temperature in a retort connected with a condenser. Acetone is the principal constituent of the distillate, to which the by-products present impart an empyreumatic odour. On addition of water, most of the liquid dissolves; the insoluble tar-like products are separated by filtration through a moistened filter-paper.

7. **Test for Acetone.**—The filtrate obtained in 6 is added to a solution of mercuric nitrate made strongly alkaline by addition of alcoholic potash. On agitating the mixture, the acetone dissolves a part of the mercuric oxide suspended in the liquid. By repeated filtration, a *clear* filtrate is obtained. On addition of ammonium sulphide to this, a precipitate of mercuric sulphide is formed, proving the presence of mercury in the solution.

8. **Addition-product of Acetone and Sodium Hydrogen Sulphite.**—5 c.c. of acetone are agitated with a like volume of a very concentrated solution of sodium hydrogen sulphite; a crystalline addition-product is precipitated, being almost insoluble in the concentrated sulphite solution. On addition of water, it dissolves.

9. **Separation of Acetone from Aqueous Solution.**—5 c.c. of acetone are added to a like volume of water, with which the



ketone is miscible in all proportions. On addition of solid caustic potash to the mixture till saturation is complete, the liquid separates into two layers, the upper one being chiefly acetone, and the lower an aqueous solution of caustic potash containing traces of acetone.

**10. Oxidation of Acetone.**—An aqueous solution of 2 c.c. of acetone is prepared, and a dilute solution of potassium permanganate added till the pink colour of the liquid persists. After removal of the manganese dioxide by filtration, the filtrate is acidified with dilute sulphuric acid and distilled. After careful neutralization with sodium carbonate, the presence of acetic acid in the distillate can be proved by the ferric-chloride test (IX, 8).

## **XI. UNSATURATED HYDROCARBONS.**

(122–134.)

### **OLEFINES (122–129).**

**1. Ethylene.**—A mixture of 20 c.c. of alcohol of eighty per cent. strength and 120 c.c. of concentrated sulphuric acid is allowed to stand for some time, preferably for a fortnight or three weeks, in order that the formation of ethylsulphuric acid may be as complete as possible. It is then heated in a large flask on a sand-bath, the tendency to foam being checked by the introduction of sand into the flask. The ethylene evolved is collected over water in cylinders, being thereby freed from most of the carbon dioxide and sulphur dioxide generated along with it.

**2. Luminosity of the Ethylene Flame.**—One of the cylinders is turned mouth upwards, and its contents ignited; the ethylene burns with a luminous flame.

**3. Action of Bromine on Ethylene.**—A small quantity of bromine-water is added to another cylinder, the open end closed

with a glass plate, and the contents agitated. The red colour is discharged, and oily drops of ethylene bromide,  $C_2H_4Br_2$ , collect on the sides of the cylinder, the characteristic odour of this compound also becoming perceptible.

**4. VON BAEYER's Test for the Double Bond.**—The gas in a third cylinder is shaken up with mixed aqueous solutions of potassium permanganate and sodium carbonate. The violet colour of the solution is discharged, and a brown precipitate of hydrated manganese dioxide,  $MnO_2, nH_2O$ , formed.

**5. Explosive Mixture of Ethylene and Oxygen.**—A thick-walled cylinder one-quarter full of ethylene is filled up with oxygen, the contents mixed by shaking, and a light applied. The mixture explodes with a loud report.

**6. Unsaturated Hydrocarbons in Coal-gas.**—Two cylinders are filled with coal-gas by displacement of water. By the application of the tests described in 3 and 4, the gas can be shown to contain unsaturated compounds.

**7. Double Linking in Amylene.**—The presence of a double linking in amylene can be demonstrated by the reactions described in 3 and 4.

#### ACETYLENE (132 and 133).

**8. Preparation of Acetylene.**—A piece of calcium carbide is dropped into water contained in a 100-c.c. fractionating-flask fitted with a delivery-tube dipping under water, and the neck of the flask quickly closed with a cork. A vigorous evolution of acetylene ensues. The gas is collected in cylinders, and submitted to the tests described in 2, 3, and 4.

**9. Copper Acetylene and Silver Acetylene.**—An ammoniacal solution of cuprous chloride is prepared by adding ammonium hydroxide to a mixture of cuprous chloride and water till solution is complete. On addition of a portion of this liquid to a cylinder containing acetylene a red precipitate of copper acetylene is formed, readily soluble in hydrochloric acid with evolution of acetylene.

An ammoniacal silver solution—prepared by adding ammonium hydroxide carefully to a solution of silver nitrate till the precipitate first formed has *just* redissolved—gives with acetylene a white precipitate of silver acetylene.

## XII. MONOBASIC UNSATURATED ACIDS.

(139-144.)

1. **Double Bond in Almond Oil.**—5 c.c. of almond oil, consisting principally of glyceryl oleate, are diluted with 10 c.c. of ether or carbon disulphide. A portion of the solution is agitated with bromine-water; the colour is discharged. To another portion is added a solution of potassium permanganate and sodium carbonate; a brown precipitate of hydrated manganese dioxide is obtained.

2. **Oleic Acid from Almond Oil.**—5 c.c. of almond oil are saponified by the method described in **IX**, 10, the heating with caustic soda being continued for not less than an hour. Periodically, water is added to replace that lost by evaporation. The resulting sodium-soap is dissolved in water, and the solution acidified with dilute sulphuric acid. The liberated oleic acid forms a liquid layer on the surface of the aqueous solution, from which it is removed by the aid of a separating-funnel. The tests for double linkings described in **XI**, 3 and 4, are carried out with portions of this acid.

3. **Elaïdic Transformation.**—Some of the liquid oleic acid is poured into 2 or 3 c.c. of a concentrated solution of sodium nitrite, a small quantity of dilute sulphuric acid added, and the mixture allowed to stand for some time. Owing to its transformation into elaïdic acid, the liquid oleic acid gradually becomes solid.

4. **Fusion of Oleic Acid with Caustic Soda.**—5 g. of solid caustic soda are heated to fusion with a few drops of water in an iron crucible, and 2 c.c. of oleic acid added. The mixture is

stirred, and maintained for some time in the fused state. After cooling, it is dissolved in water, and excess of dilute sulphuric acid added. On distillation from a fractionating-flask, an acid distillate is obtained, containing acetic acid.

**5. Lead Oleate.**—A mixture of 5 c.c. of almond oil, 25 c.c. of water, and 10 g. of lead monoxide is boiled for not less than an hour in a porcelain dish, and constantly stirred. Water is added periodically to replace that lost by evaporation. After cooling, the water is poured off, and the plaster-like lead oleate (so-called "lead-plaster") formed is triturated thoroughly with ether by the aid of a pestle. After filtering, and distilling the ether, the lead oleate is left in the semi-solid state. Addition of sulphuretted-hydrogen water proves the presence of lead, giving a black precipitate of lead sulphide.

### XIII. CHLOROFORM AND IODOFORM.

(150–152.)

**1. Preparation of Chloroform.**—25 g. of fresh bleaching-powder, 10 c.c. of alcohol of eighty-five per cent. strength, and 10 c.c. of water are heated gently in a litre flask on a sand-bath till the reaction begins; the flame is then removed. There is much foaming, and water and chloroform distil, the latter constituting the lower layer of the distillate.

**2. Action of Caustic Potash on Chloroform.**—A few drops of chloroform are heated in a test-tube with a small quantity of dilute caustic potash, potassium chloride and potassium formate being produced. The mixture is neutralized so as to maintain a slightly alkaline reaction, and heated with a solution of mercuric chloride. Reduction to mercurous chloride, and then to metallic mercury, proves the presence of dissolved formate (IX, 2).

**3. Conversion of Chloroform into Potassium Cyanide.**—1 c.c. of chloroform is heated in a test-tube for a short time with 5 c.c. of concentrated alcoholic ammonia and 1 c.c. of concentrated

alcoholic potash. The liquid is transferred to a porcelain dish, and evaporated to dryness on a water-bath. The presence of potassium cyanide in the residue is detected by the method employed in LASSAIGNE'S test for nitrogen (I, 3 a).

**4. Chloroform and Silver Nitrate.**—1 c.c. of chloroform is agitated three or four times with water in a test-tube, using about 10 c.c. for each operation; this eliminates traces of hydrochloric acid, if present. More water and 2 or 3 drops of silver-nitrate solution are then added. A precipitate of silver chloride is not formed.

**5. Iodoform Test for Alcohol.**—To 1 c.c. of alcohol in a test-tube are added 10 c.c. of a moderately concentrated solution of iodine in potassium-iodide solution, and caustic-potash solution drop by drop till the brown colour of the iodine is discharged. A yellow, crystalline precipitate of iodoform is obtained, distinguished by its characteristic odour. Under the microscope, the crystals are seen to be six-sided plates.

## XIV. GLYCEROL.

(157–160.)

**1. Preparation of Allyl Alcohol.**—10 c.c. of glycerol and 12 g. of crystallized oxalic acid are heated in a retort connected with a condenser. At first, formic acid distils (IX, 1), and soon oily streaks of allyl alcohol are seen on the sides of the retort. The distillation is continued with another receiver, this alcohol passing over. It is characterized by an irritating odour. On heating it with chromic-acid solution, the powerful, penetrating odour of acrolein is perceived.

**2. Test for Glycerol.**—1 c.c. of glycerol is heated in a dish with 5 g. of sodium pyrosulphate,  $\text{Na}_2\text{S}_2\text{O}_7$ ; the odour of acrolein is soon perceived.

**3. Action of Alkalis on Copper Salts in Presence of Glycerol.**—To 1 c.c. of glycerol are added 5 c.c. of dilute copper-sulphate

solution. On addition of caustic potash to this mixture, copper hydroxide,  $\text{Cu}(\text{OH})_2$ , is not precipitated. Instead, a soluble copper alkoxide of glycerol is formed, imparting a deep-blue colour to the solution.

**4. BAUMANN and SCHOTTEN's Test for Hydroxyl-groups.**—A solution of 1 c.c. of glycerol in 2 c.c. of water is agitated with 4 c.c. of benzoyl chloride, until the odour of the chloride is no longer perceptible, caustic-potash solution being added slowly so as to maintain a slight alkaline reaction. The solid glyceryl tribenzoate formed is recrystallized from alcohol, the crystals dried between filter-paper, and their melting-point taken. M. P.  $74^\circ$ .

## XV. SATURATED DIBASIC ACIDS.

(163–167.)

### OXALIC ACID (165).

**1. Preparation of Oxalic Acid from Wood.**—A concentrated solution of caustic potash (not soda) is added to 10 g. of sawdust, so as to form a thick paste. This is heated gently on a shallow iron dish, and constantly stirred. The first product is potassium formate; on further heating, this loses hydrogen, yielding potassium oxalate (2). The heating is continued for a few minutes after rapid evolution of hydrogen from the mass in large bubbles which burn on ignition has begun, and then stopped, to prevent decomposition of the oxalate formed. When cold, the reaction-mixture is lixiviated with water, filtered through a folded filter, and acidified with dilute acetic acid. On addition of calcium-chloride solution, calcium oxalate is precipitated, insoluble in acetic acid, but soluble in cold, and more readily in warm, hydrochloric acid.

**2. Conversion of Formates into Oxalates.**—2 g. of dried sodium formate are heated to a high temperature in a test-tube closed with a cork and glass jet. Hydrogen is evolved, and can

be ignited after all the air has been expelled from the tube. The white residue is proved to be sodium oxalate by dissolving it in water, and adding a solution of calcium chloride; a precipitate of calcium oxalate, insoluble in dilute acetic acid, is formed.

**3. Calcium, Lead, and Copper Oxalates.**—These are prepared by adding solutions of calcium chloride, lead acetate, and copper sulphate respectively to a ten per cent. solution of ammonium oxalate till precipitation is complete, 50 c.c. of the ammonium-oxalate solution being used for each experiment. The salts are collected on filters, washed thoroughly with water, and spread on porous plates to dry. The last traces of moisture are eliminated by heating them in porcelain dishes on the water-bath.

**4. Decomposition of Calcium Oxalate by Heat.**—3 g. of calcium oxalate are heated in a hard-glass test-tube fitted with a delivery-tube. When the temperature has risen above 200°, water of crystallization condenses on the sides of the tube; on further heating, carbon monoxide is evolved. The gas is collected in a cylinder, and its identity established by the method of **IX**, 3. The residue in the tube is calcium carbonate; when cold, it is treated with hydrochloric acid, causing a vigorous evolution of gas. This is proved to be carbon dioxide by its action on lime-water.

**5. Decomposition of Lead and Copper Oxalates by Heat.**—The experiment described in 4 is carried out in separate tubes with 3 g. of lead oxalate and a like weight of copper oxalate. Both evolve carbon dioxide, as proved by the lime-water test; lead and copper remain in the tubes.

**6. Action of Concentrated Sulphuric Acid on Oxalic Acid.**—A 100-c.c. distilling-flask is connected with a wash-bottle containing a mixture of caustic-potash solution and lime-water, and fitted with a delivery-tube. In the flask are placed 5 g. of oxalic acid and 10 c.c. of concentrated sulphuric acid. The flask is closed with a cork, and heated gently. Gas is evolved; partly carbon dioxide, which renders turbid the lime-water in

the wash-bottle; and partly carbon monoxide, which is not absorbed. The latter is collected in cylinders, and identified by the method of **IX**, 3.

**7. Complex Oxalates.**—*a*) A solution of ammonium oxalate is added carefully to 2 c.c. of a five per cent. solution of copper sulphate. Copper oxalate is precipitated, and, on further addition of the ammonium salt, redissolves, forming copper ammonium oxalate.

*b*) A solution of 2 g. of "salt of sorrel,"  $\text{KHC}_2\text{O}_4 + \text{H}_2\text{C}_2\text{O}_4 + 2\text{H}_2\text{O}$ , in 10 c.c. of water is prepared. To this is added freshly-precipitated ferric hydroxide, obtained by adding ammonium hydroxide to a boiling, dilute solution of ferric chloride, allowing the precipitate to subside, and washing it by decantation. On warming, the ferric hydroxide dissolves, yielding potassium ferric oxalate,  $\text{K}_3\text{Fe}(\text{C}_2\text{O}_4)_3$ . The *green* colour of this solution should be noted; it points to the absence of  $\text{Fe}^{2+}$ -ions, and to the presence of complex  $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ -anions.

*c*) A like solution of "salt of sorrel" is added to 5 c.c. of a ten per cent. solution of ferrous sulphate until the precipitate first formed redissolves. The *yellow* colour of this solution is due to the complex  $[\text{Fe}(\text{C}_2\text{O}_4)_2]^{-}$ -anion.

**8. Dimethyl Oxalate.**—Oxalic acid is dried at  $100^\circ$ , and 3 g. of the dry acid are dissolved in 10 c.c. of boiling methyl alcohol. On cooling, dimethyl oxalate crystallizes out. Some of the ester is dried by pressure between sheets of filter-paper, and its melting-point taken. M. P.  $54^\circ$ .

**9. Diethyl Oxalate.**—A mixture of 7 g. of anhydrous oxalic acid and 10 c.c. of absolute alcohol is heated slowly in a 50-c.c. fractionating-flask connected with a condenser till the temperature rises to  $110^\circ$ . The distillate is then returned to the flask, and the heating continued till the thermometer reaches  $180^\circ$ . The fraction distilling between this temperature and  $190^\circ$  is collected separately, and is principally diethyl oxalate.

**10. Oxamide.**—The esters obtained in experiments 8 and 9 are dissolved separately in alcohol, and ammonium hydroxide



added to each solution. From both a precipitate of oxamide is obtained, insoluble in water, alcohol, and ether.

### SUCCINIC ACID (167).

**11. Barium Succinate.**—Ammonium hydroxide is added to 10 c.c. of a cold, saturated solution of succinic acid till neutralization is complete. On addition of barium chloride, a white, crystalline precipitate of barium succinate is formed, the precipitation being facilitated by addition of alcohol.

**12. Basic Ferric Succinate.**—10 c.c. of a solution of succinic acid are carefully neutralized, and ferric chloride added. A brown, gelatinous precipitate of basic ferric succinate is formed.

**13. Succinimide.**—A solution of 10 g. of succinic acid in ammonium hydroxide is evaporated in a porcelain dish on a sand-bath, and heated till the temperature of the fused mass is about 200°. The residue is transferred to a small fractionating-flask, and distilled as rapidly as possible. The distillate is succinimide, M. P. 125°. It can be crystallized from alcohol.

## XVI. HYDROXY-ACIDS OR ALCOHOL-ACIDS.

(182–198.)

### LACTIC ACID (185).

**1. Decomposition of Lactic Acid by Dilute Sulphuric Acid.**—5 c.c. of lactic acid are heated with a mixture of 5 c.c. of concentrated sulphuric acid and 10 c.c. of water in a retort connected with a condenser. The distillate contains acetaldehyde and formic acid. These can be identified by the silver-mirror test (X, 2), and the mercuric-oxide test (IX, 2), respectively.

**2. Decomposition of Lactic Acid by Concentrated Sulphuric Acid.**—A mixture of 5 c.c. of lactic acid and a like volume of concentrated sulphuric acid is heated in a retort fitted with a delivery-tube. The gas evolved by the decomposition of the

formic acid first produced can be proved to be carbon monoxide by the method described in **IX**, 3.

**3. Test for Hydroxyl-groups with Phosphorus Pentachloride.**—Ethyl lactate is prepared by distilling an intimate mixture of 13 g. of potassium ethylsulphate and 10 g. of calcium lactate. The ester is dried by contact with granulated calcium chloride till no longer cloudy, and then poured over a small quantity of phosphorus pentachloride. This replaces its OH-group by Cl, evolving hydrochloric-acid gas, and forming  $\alpha$ -chloropropionic acid. The mixture is poured into water, and the oil which sinks to the bottom agitated several times with small quantities of water, till this no longer gives a precipitate with silver nitrate. On applying **BEILSTEIN's** test (**I**, 4 a) to the oil, a green colouration is obtained, indicating the presence of chlorine.

#### **TARTARIC ACID (192–197).**

**4. Potassium Tartrates.**—Caustic potash is added drop by drop to 5 c.c. of a twenty per cent. solution of tartaric acid. A precipitate of potassium hydrogen tartrate is first formed, and, on further addition of caustic potash, redissolves, with production of the neutral tartrate.

**5. Iron Ammonium Tartrate.**—A solution of 9 g. of ferrous sulphate is added to 15 c.c. of a solution of 1 part of tartaric acid in 2 parts of water; excess of ammonium hydroxide produces no precipitate with this mixture. When agitated in presence of air, this liquid absorbs oxygen, becoming light-green, then dark-green, and finally brown. The absorption of oxygen can be demonstrated by carrying out the process in a flask closed with an air-tight cork; on immersion of the neck in water and removal of the cork, the water rises in the flask. After replacement of the cork, the flask is withdrawn from the water, and an ignited wood-splint introduced into the residual gas; the flame is at once extinguished.

**6. FEHLING's Solution.**—A solution of copper sulphate is

added to one of tartaric acid, and then caustic potash in excess. The dark-blue liquid formed is known as *FEHLING'S solution*.

**7. Action of Heat on Tartaric Acid.**—When heated in a test-tube, tartaric acid becomes brown, and acquires a caramel-like odour.

**8. Microchemical Method of Distinguishing between Tartaric Acid and Racemic Acid.**—*a*) Addition of calcium chloride to a solution of tartaric acid saturated with ammonia gives a precipitate of calcium tartrate, somewhat soluble in acetic acid, and readily soluble in caustic potash and caustic soda.

*b*) The last experiment is repeated with a solution of racemic acid saturated with ammonia, and the crystals of calcium tartrate compared under the microscope with those of calcium racemate.

**9. Tartar Emetic.**—A solution of potassium hydrogen tartrate is prepared by dissolving 1 g. of tartaric acid in a small quantity of water, neutralizing with caustic potash, and adding a concentrated solution of a second gramme of tartaric acid. The precipitated potassium hydrogen tartrate is redissolved by heating, after addition of a little water. To this solution is added antimony oxide; it dissolves, forming *tartar emetic*.

#### CITRIC ACID (198).

**10. Preparation from Lemons.**—A small quantity of water is added to 10 c.c. of lemon-juice, the mixture filtered, and made alkaline with ammonium hydroxide. On addition of calcium chloride, no precipitate is formed; on boiling the mixture, tricalcium citrate is precipitated, and is redissolved as the liquid cools.

**11. Action of Concentrated Sulphuric Acid on Citric Acid.**—A solution of 5 g. of citric acid in cold, concentrated sulphuric acid is heated in a distilling-flask, fitted with a delivery-tube. The carbon monoxide evolved is identified by the method described in **IX, 3 (243)**.

**XVII. CHLORAL HYDRATE.**

(204.)

1. **Action of Water on Chloral.**—3 g. of chloral hydrate are covered with concentrated sulphuric acid, and the mixture agitated. An oily layer of anhydrous chloral collects on the surface of the acid. This is separated from the sulphuric acid by the aid of a 50-c.c. tap-funnel, and brought into contact with a *small* quantity of water; heat is evolved, and solid chloral hydrate formed.

2. **Action of Caustic Potash on Chloral Hydrate.**—A small quantity of caustic-potash solution is added to 1 g. of chloral hydrate dissolved in 10 c.c. of water. The odour of chloroform becomes perceptible, and the liquid is rendered turbid by the separation of minute drops of this substance. The presence of formic acid in the solution is proved by warming it, after careful neutralization and addition of a small quantity of mercuric chloride or silver nitrate (IX, 2).

3. **Silver-mirror Test for Chloral Hydrate.**—A dilute solution of chloral hydrate is warmed in a test-tube on a water-bath with a small quantity of an ammoniacal solution of silver nitrate, prepared in accordance with the method described in X, 2. If the tube is clean, a silver mirror is deposited on its sides.

**XVIII. ALDEHYDE AND KETONE ALCOHOLS OR SUGARS.**

(206–231.)

**PROPERTIES OF THE MONOSES (207 and 208).**

1. **Silver-mirror Test.**—A ten per cent. solution of glucose is warmed in a clean test-tube in a water-bath with an ammoniacal solution of silver nitrate prepared as in X, 2. A silver mirror forms on the inner surface of the test-tube.

**2. Resinification with Caustic Alkalis.**—A similar solution is boiled with a small amount of caustic-potash or caustic-soda solution. The liquid turns yellow, then brown, and finally resinifies.

**3. Reduction of FEHLING'S Solution.**—On heating another portion of the glucose solution with FEHLING'S solution (XVI, 6), reduction takes place, with formation of red cuprous oxide.

**4. Osazones.**—A solution of phenylhydrazine in excess of dilute acetic acid is added to another portion of the glucose solution in a test-tube. On warming the mixture in a water-bath, glucosazone precipitates in the form of microscopic, yellow needles.

#### METHODS OF FORMATION OF THE MONOSES (210).

**5. Inversion of Sucrose (Cane-sugar).**—A dilute solution of sucrose is boiled for several minutes with a few drops of dilute sulphuric acid. After this treatment, the solution answers to the glucose tests described in 1-4.

**6. Glycerose.**—A mixture of 10 g. of glycerol and 20 c.c. of nitric acid of 1.18 specific gravity is heated in a beaker on the water-bath until oxides of nitrogen are evolved, and cooled quickly. After neutralization of the solution with caustic potash or soda, the presence of glycerose can be demonstrated by reactions 1-4.

#### PENTOSES (211).

**7. Furfuraldehyde Test.**—To 10 g. of bran contained in a half-litre flask is added a mixture of 5 g. of concentrated sulphuric acid and 70 c.c. of water. The flask is connected with a condenser, and heated. The distillate contains furfuraldehyde (391), characterized by an agreeable odour. This aldehyde can be identified in two ways.

a) On addition of a small quantity of aniline to the solution, followed by concentrated hydrochloric acid, the liquid acquires an intense red colour.

b) A solution of phenylhydrazine in dilute acetic acid is added to the mixture containing furfuraldehyde, whereupon furfuraldehyde-hydrazone is precipitated in the form of an oil, which soon crystallizes.

### HEXOSES (212).

**8. Hydrochloric-acid Test.**—A solution of a hexose is boiled with concentrated hydrochloric acid. The liquid becomes brown, and deposits “humus substances”; lævulinic acid remains in solution (236).

### *d*-Glucose (212, 1).

**9. Calcium Alkoxide of *d*-Glucose.**—Milk of lime is added drop by drop to 10 c.c. of a solution of 1 part of *d*-glucose in 2 parts of water, and the mixture agitated. The lime dissolves, forming the calcium alkoxide or saccharate of *d*-glucose. This is decomposed by carbon dioxide, with precipitation of calcium carbonate.

**10. Glucosesulphuric Acid.**—1 g. of *d*-glucose is triturated in a mortar with cold, concentrated sulphuric acid, added drop by drop till solution is complete. Glucosesulphuric acid is formed, and can be detected by diluting with water, adding barium carbonate till the mixture, thoroughly blended by the aid of the pestle, ceases to be acid, and filtering; the filtrate contains the barium salt of glucosesulphuric acid. Addition of dilute sulphuric acid decomposes the barium glucosesulphate, precipitating barium sulphate.

**11. Copper Alkoxide of *d*-Glucose.**—A small quantity of a solution of 1 part of *d*-glucose in 2 parts of water is added to 2 c.c. of a ten per cent. solution of copper sulphate. On addition of caustic potash to the mixture, no precipitate is formed, the formation of a copper alkoxide of glucose imparting a dark-blue colour to the solution.

**12. Detection of *d*-Glucose in Urine.**—Caustic-soda solution and a little bismuth nitrate are added to a five per cent. solution of *d*-glucose, and the mixture boiled. Black bismuthous oxide, BiO, is precipitated.

**13. Oxidation of *d*-Glucose by Nitric Acid.**—A mixture of 1 g. of *d*-glucose and 10 c.c. of nitric acid of 1.3 specific gravity is evaporated to dryness on the water-bath. About 1 c.c. of water is added to the residue, and 5 c.c. of a concentrated solution of potassium acetate. After a short time, potassium hydrogen saccharate is precipitated.

#### *d*-Fructose (212, 2).

**14. Alcoholic Character.**—The alcoholic character of this compound can be demonstrated by the methods employed for *d*-glucose (9-11).

**15. Test for *d*-Fructose.**—1 c.c. of a ten per cent. solution of *d*-fructose is heated with concentrated hydrochloric acid and some crystals of resorcinol. The liquid turns dark-red.

#### *d*-Galactose (212, 6).

**16. Oxidation of *d*-Galactose to Mucic Acid.**—A solution of 1 g. of *d*-galactose is boiled for several minutes with nitric acid of 1.3 specific gravity, evaporated to small bulk, diluted with water, and cooled. Mucic acid separates as a crystalline powder, soluble with difficulty in cold water. If *d*-galactose cannot be obtained, lactose should be used instead (216).

A small quantity of the mucic acid is washed with water to remove traces of nitric acid, dissolved in dilute caustic potash, and a drop of the solution allowed to evaporate to dryness on a microscope-slide. Under the microscope, the residue is seen to contain the characteristic, prismatic crystals of potassium mucate.

**HEXODIOSES (215-223).****Sucrose (217-221).****17. Properties Distinguishing Sucrose from the Monoses.—**

When heated with caustic alkalis, a ten per cent. solution of sucrose does not resinify; it does not reduce FEHLING's solution; and, when warmed with a solution of phenylhydrazine in dilute acetic acid, gives no osazone (1-4).

**18. Action of Heat on Sucrose.**—On heating a small quantity of sucrose in a test-tube, it turns brown, forming caramel, and evolving the characteristic odour of this substance.

**19. Tricalcium Saccharate.**—10 c.c. of a twenty per cent. solution of sucrose are agitated with sufficient milk of lime to cause permanent turbidity, and filtered. When the filtrate is boiled, the nearly insoluble tricalcium saccharate,  $C_{12}H_{22}O_{11} \cdot 3CaO + 3H_2O$ , is precipitated.

**20. Inversion.**—A solution of 2 g. of sucrose is inverted by boiling for several minutes with dilute sulphuric acid. After careful neutralization with caustic soda, the solution thus obtained has the properties characteristic of monoses, described in 1-4.

**Lactose (216).**

**21. Detection of Lactose in Milk.**—A few drops of dilute acetic acid are added slowly to 25 c.c. of milk diluted with a like volume of water, the liquid being thoroughly mixed by stirring. The casein and fatty constituents of the milk are thus precipitated. The mixture is filtered through a folded filter. On warming part of the filtrate with FEHLING's solution, the lactose causes reduction, with formation of red cuprous oxide. The rest of the filtrate is evaporated with dilute nitric acid to small bulk; *d*-galactose is formed by inversion, and oxidized to mucic acid, which can be recognized by the method of 16.



22. **Lactosazone.**—On warming 5 c.c. of a ten per cent. solution of lactose with an acetic-acid solution of phenylhydrazine, an osazone—lactosazone—is formed.

23. **"Sand-sugar."**—The taste of lactose is not so sweet as that of sucrose, and in the mouth it resembles sand, hence the name sand-sugar.

### POLYPOSES (224–231).

#### Starch (226 and 227).

24. **Starch-paste.**—5 g. of powdered starch are washed with water on a filter-paper. The washed starch is transferred to a beaker containing 200 c.c. of boiling water, a faintly opalescent solution of starch-paste being obtained.

25. **Properties Distinguishing Starch from the Monoses.**—If the starch has been washed with sufficient care, this starch-paste does not reduce FEHLING's solution, and is not resinified by alkalis.

26. **Conversion of Starch into *d*-Glucose.**—50 c.c. of the starch-paste solution are boiled with 10 c.c. of ten per cent. sulphuric acid for fifteen minutes. After neutralization with caustic soda, the liquid has the properties characteristic of monoses described in 1–4.

27. **Iodine Test for Starch.**—A trace of an iodine solution is added to one of starch-paste, a deep-blue colouration being produced. On heating, this disappears, but on cooling returns, provided the heating is not too prolonged.

28. **Barium Alkoxide of Starch.**—A solution of barium hydroxide is added to a boiling solution of starch-paste. The barium alkoxide of starch is precipitated.

29. **Conversion of Starch into Dextrin.**—A small quantity of starch is heated carefully in a test-tube, the residue agitated with cold water, and filtered. The filtrate contains dextrin, proved by the yellow colouration developed by heating with

alkalis, and its precipitation from solution on addition of alcohol.

**30. Potato-starch.**—A small quantity of potato-starch is moistened with a few drops of water, a little of the mixture transferred to a microscope-slide, and examined under the microscope. The starch-granules are seen to have a characteristic shell-like appearance (226, Fig. 69).

### Cellulose (229-231).

**31. Hydrolysis of Cellulose.**—A piece of filter-paper is dissolved in cold, concentrated sulphuric acid by the method described in 10, the solution poured into water, and boiled for half an hour. When neutralized with caustic soda, it answers to the tests for monoses (1-4).

**32. Parchment-paper.**—A strip of filter-paper is immersed in sulphuric acid containing half its volume of water, and at once transferred to a large quantity of cold water, and thoroughly washed. This converts the cellulose into amyloid or parchment-paper, which gives a blue colouration with iodine. Although wet, the parchment-paper is very tough, and cannot be torn readily.

**33. Solubility of Cellulose in SCHWEITZER's Reagent.**—An ammoniacal solution of copper oxide is prepared by adding freshly-precipitated, washed copper hydroxide to 10 c.c. of concentrated ammonium hydroxide till no more dissolves. When placed in this, filter-paper (cellulose) dissolves. On addition of dilute hydrochloric acid to the solution, the colour is discharged, and an amorphous, flocculent precipitate of cellulose deposited.

**34. Nitrates of Cellulose.**—A small piece of cotton-wool is immersed for several seconds in a cold mixture of one part of concentrated nitric acid and two parts of concentrated sulphuric acid, nitrates of cellulose being formed. It is then washed carefully with much cold water, and dried at the ordi-

nary temperature. A part held with tongs in a Bunsen flame burns energetically. Another portion is agitated with a mixture of alcohol and ether, and the liquid—a solution of collodion—poured on a glass plate; on evaporation of the solvent, a transparent skin is left.

The remainder of the cellulose nitrates is moistened with a small quantity of ethyl acetate. A gelatinous mass is formed, which, when dry, burns slowly. In this form guncotton is employed in artillery, under the name “smokeless powder.”

**35. Detection of Lignin in Paper.**—A sheet of paper is coated with a solution of aniline in hydrochloric acid. If made from wood, the paper acquires a yellow colour (230).

## **XIX. HYDROCYANIC ACID, AND ITS SIMPLE AND COMPLEX SALTS.**

(242 and 243.)

**1. Hydrocyanic Acid.**—10 c.c. of a cold, saturated solution of potassium ferrocyanide are poured into a distilling-flask connected with a condenser, and 20 c.c. of twenty per cent. sulphuric acid added. The open end of the condenser is dipped into a test-tube containing water and a few drops of concentrated caustic potash or soda. On heating, hydrocyanic acid distils, and is converted into potassium cyanide.

**2. Prussian-blue Test.**—To part of the solution obtained in the last experiment is added a mixture of a ferrous salt and a ferric salt. On acidifying with hydrochloric acid, a precipitate of Prussian blue is formed (I, 3 a).

**3. Silver Cyanide.**—A drop of a dilute solution of silver nitrate is added to 10 c.c. of a solution of 1 g. of potassium cyanide in 100 c.c. of water. On agitating the mixture, the precipitate first formed redissolves, yielding a double cyanide of potassium and silver,  $\text{KAg}(\text{CN})_2$ . On further addition of silver

nitrate, a permanent precipitate of silver cyanide,  $\text{AgCN}$ , is obtained.

**4. Hydrolysis of Potassium Cyanide.**—25 c.c. of the solution of potassium cyanide prepared for experiment 3 are boiled in a flask. The evolved ammonia turns a strip of red litmus-paper blue.

**5. Conversion of Ammonium Formate into Hydrocyanic Acid.**—3 g. of ammonium formate are submitted to dry distillation in a small distilling-flask connected with a condenser dipping into a test-tube with very dilute caustic soda. The presence of hydrocyanic acid in the distillate can be demonstrated by the Prussian-blue test (2).

**6. Double Ferrocyanide of Potassium and Calcium.**—A small quantity of a calcium-chloride solution is added to a cold, saturated solution of potassium ferrocyanide. The double ferrocyanide,  $\text{K}_2\text{CaFe}(\text{CN})_6$ , is precipitated.

**7. Ferrocyanic Acid.**—Concentrated hydrochloric acid is added to 5 c.c. of a strong solution of potassium ferrocyanide. White ferrocyanic acid,  $\text{H}_4\text{Fe}(\text{CN})_6$ , is precipitated. When collected on a filter-paper, it soon turns blue, Prussian blue being formed by decomposition and oxidation.

**8. Action of Concentrated Sulphuric Acid on Potassium Ferrocyanide.**—5 g. of potassium ferrocyanide are warmed with concentrated sulphuric acid in a fractionating-flask. The evolved carbon monoxide can be identified by the method described in **IX**, 3.

**9. Action of Heat on Potassium Ferrocyanide.**—2 g. of potassium ferrocyanide are heated to redness in a crucible; when cold, the residue is lixiviated with water, and the mixture filtered quickly. The solution contains potassium cyanide, as can be proved by the Prussian-blue and silver-nitrate tests (2 and 3).

**10. Potassium Ferricyanide.**—Bromine-water is added to a solution of potassium ferrocyanide, which converts it into potassium ferricyanide. This is proved by addition of ferric

chloride, which produces a brown colouration, instead of a precipitate of Prussian blue.

**11. Reduction of Potassium Ferricyanide.**—Litharge,  $\text{PbO}$ , is added to a solution of potassium ferricyanide containing caustic potash. The solid becomes brown, the lead monoxide being oxidized to lead dioxide,  $\text{PbO}_2$ . After filtering, and adding ferric chloride to the filtrate, a precipitate of Prussian blue is formed, proving the presence of potassium ferrocyanide.

**12. Oxidation of Potassium Ferrocyanide by Potassium Permanganate.**—Sulphuric acid is added to a dilute solution of potassium ferrocyanide. This mixture decolourizes potassium permanganate, forming potassium ferricyanide, which gives a brown colouration with ferric chloride.

## **XX. POTASSIUM CYANATE AND POTASSIUM THIOCYANATE.**

(244 and 245.)

**1. Potassium Cyanate.**—Litharge,  $\text{PbO}$ , is added to 3 g. of fused potassium cyanide in a crucible so long as reduction to metallic lead is rapid. The potassium cyanate,  $\text{KCNO}$ , formed is extracted with water. On addition of sulphuric acid, carbon dioxide is evolved, since the liberated cyanic acid reacts at once with the water to form carbon dioxide and ammonia. The liquid in the flask is made alkaline with caustic soda, and heated. The evolved ammonia turns blue a strip of moist, red litmus-paper held in the mouth of the flask.

**2. Potassium Thiocyanate.**—10 c.c. of potassium-cyanide solution are boiled for some minutes with “flowers of sulphur,” and filtered. Addition of ferric chloride to the filtrate gives a blood-red colouration, proving the formation of potassium thiocyanate.

**3. Silver Thiocyanate.**—With silver nitrate a solution of potassium thiocyanate produces a white, cheese-like precipi-

tate of silver thiocyanate,  $\text{AgCNS}$ , insoluble in dilute nitric acid.

## XXI. DERIVATIVES OF CARBONIC ACID.

(248-256.)

### CARBON DISULPHIDE (250).

**1. Inflammability.**—A few drops of carbon disulphide are poured into a porcelain basin, and ignited. The liquid burns with a blue flame, forming carbon dioxide and sulphur dioxide, the presence of the latter being made evident by its characteristic, suffocating odour.

**2. Volatility.**—On blowing upon a few drops of carbon disulphide in the palm of the hand, a sensation of cold is experienced.

**3. Solvent Power.**—Some linseed is crushed in a mortar, transferred to a test-tube, and covered with a small quantity of carbon disulphide. After about a minute, the liquid is poured on a clock-glass or watch-glass, and allowed to evaporate spontaneously. The residue is linseed oil.

**4. Barium Trithiocarbonate.**—5 g. of barium sulphide are boiled with water for a few seconds, and the mixture filtered. About 1 c.c. of carbon disulphide is added to the warm filtrate, the mixture vigorously shaken, and allowed to cool. A yellow precipitate of barium trithiocarbonate is deposited.

**5. Potassium and Copper Salts of Xanthic Acid.**—10 c.c. of a twenty per cent. solution of caustic potash in absolute alcohol is agitated with successive quantities of carbon disulphide, till potassium xanthate separates out. The precipitation of the salt is facilitated by addition of a small amount of ether. It is collected on a filter, dried between layers of filter-paper, and dissolved in water. On adding a solution of copper sulphate, a brownish-black precipitate of cupric xanthate is formed. This changes so quickly to yellow cuprous xanthate as to be hardly perceptible.

## UREA (252 and 253).

**6. WÖHLER'S Synthesis.**—Potassium cyanate, prepared by the method of **XX**, 1, is dissolved in water. Ammonium sulphate is added, producing potassium sulphate and ammonium cyanate. The solution is evaporated almost to dryness on the water-bath, and the urea formed by the intramolecular rearrangement of the ammonium cyanate extracted with alcohol. The solvent is distilled, leaving a residue of urea.

**7. Urea Oxalate.**—The urea obtained in the last experiment is dissolved in a very small quantity of water, and a concentrated solution of oxalic acid added. A crystalline precipitate of urea oxalate is deposited.

**8. Urea Nitrate from Urine.**—About 10 c.c. of urine are evaporated to small bulk on a water-bath, and the residue allowed to cool. On addition of a few cubic centimetres of colourless nitric acid of 1.4 specific gravity, a precipitate of urea nitrate is formed. The mother-liquor is poured off, and the nitrate purified by crystallization from a small quantity of hot water.

**9. KNOP'S Method for the Estimation of Urea in Urine.**—A solution of bromine in cold caustic potash (German, *Bromlauge*) is added to 10 c.c. of urine contained in a distilling-flask fitted with a delivery-tube. The urea at once begins to decompose, evolving nitrogen. This is collected over water, and tested with a lighted taper.

**10. BUNSEN'S Method for the Estimation of Urea in Urine.**—10 c.c. of urine are heated with baryta-water in a flask. A strip of red litmus-paper held in the mouth of the flask is turned blue by the ammonia liberated. At the same time, the precipitated barium carbonate renders the liquid turbid.

**11. LIEBIG'S Method for the Estimation of Urea in Urine.**—A solution of mercuric nitrate is added to 10 c.c. of a two per cent. solution of urea. A white precipitate of the composition  $2\text{CON}_2\text{H}_4 \cdot \text{Hg}(\text{NO}_3)_2 \cdot 3\text{HgO}$  is formed. When excess of the mercuric nitrate has been added, a drop of the solution brought

into contact with one of sodium carbonate gives a yellow precipitate of basic nitrate of mercury.

**12. Action of Heat on Urea.**—1 g. of urea is carefully heated in a test-tube; it melts, and evolves ammonia, which can be identified by means of a strip of red litmus-paper. The fused mass soon re-solidifies, and the heating is stopped. The residue is lixiviated with a *small* quantity of cold water, biuret going into solution. This substance can be identified by the *biuret reaction*. Caustic potash and one or two drops of a ten per cent. solution of copper sulphate are added to the liquid; the violet-red colouration produced is due to the formation of a copper compound of biuret.

**13. Cyanuric Acid.**—This substance is the principal constituent of the residue in the test-tube after solution of the biuret in the last experiment. It is dissolved in warm water; after cooling, addition of copper sulphate and ammonium hydroxide gives a crystalline, violet precipitate of copper ammonium cyanurate.

#### CARBAMIC ACID (254).

**14. Calcium Carbamate.**—Ammonium hydroxide is added to 10 c.c. of a ten per cent. solution of calcium chloride. On passing carbon dioxide through the mixture, no precipitate is obtained, the calcium carbamate formed being soluble in water. When the solution is warmed, the carbamate decomposes, precipitating calcium carbonate.

**15. Ammonium Dithiocarbamate.**—A drop of carbon disulphide is added to a strong alcoholic solution of ammonia, and the mixture evaporated to dryness in a porcelain dish on a water-bath. Ammonium dithiocarbamate is formed first, but decomposes into ammonium thiocyanate and ammonium sulphide. The latter volatilizes, and the presence of the former in the residue can be demonstrated by dissolving it in water, acidifying the solution with dilute hydrochloric acid, and adding ferric chloride. A blood-red colouration is obtained, caused by the formation of ferric thiocyanate (XX, 2).



**XXII. URIC ACID GROUP.**

(257 and 258.)

**1. Ammonium Urate.**—A mixture of 50 c.c. of urine and 2.5 c.c. of a concentrated solution of sodium carbonate is placed in a flask, and 5 c.c. of a saturated ammonium-chloride solution added. After a short interval, ammonium urate is precipitated.

**2. Di-potassium Urate.**—A small quantity of uric acid is agitated with water; it does not dissolve. On addition of dilute caustic potash, the readily soluble di-potassium salt is formed, and can be reconverted into uric acid by dilute acids.

**3. Murexide Test for Uric Acid.**—A few cubic centimetres of nitric acid of 1.4 specific gravity are added to 0.5 g. of uric acid in a porcelain dish, and the mixture evaporated nearly to dryness on a water-bath. In addition to other products, alloxantine is formed. When treated with ammonium hydroxide, it forms a purple-red dye—murexide, the ammonium salt of purpuric acid.

**4. Reduction of Silver Nitrate by Uric Acid.**—A small quantity of uric acid is dissolved in a few drops of sodium-carbonate solution. When this is brought into contact with filter-paper moistened with a solution of silver nitrate, a black stain of metallic silver is formed, in consequence of the reducing action of the uric acid.

**5. Murexide Test for Caffeine.**—A few cubic centimetres of nitric acid of 1.4 specific gravity are added to 0.5 g. of caffeine in a porcelain dish, and evaporated almost to dryness on a water-bath. A yellow stain of amalic acid, or tetramethyl-alloxantine, is left. On moistening this with ammonium hydroxide, it becomes purple.

**XXIII. BENZENE AND ITS HOMOLOGUES.**

(263–270.)

**1. Stability of Benzene towards the Halogens.**—On agitating a few cubic centimetres of benzene with bromine-water, the colour is not discharged.

**2. Absence of Double Bonds in Benzene.**—Benzene is agitated with a solution of potassium permanganate and sodium carbonate—VON BAEYER's reagent (123 and 263). The violet-red colour remains unaltered.

**3. Nitrobenzene.**—2 c.c. of benzene are added drop by drop to a mixture of 4 c.c. of concentrated sulphuric acid and 2 c.c. of nitric acid of 1.5 specific gravity, the flask being cooled with running water to prevent rise of temperature. The benzene dissolves, and, on pouring the acid mixture into water, nitrobenzene separates and sinks to the bottom. It has a characteristic odour, resembling that of oil of bitter almonds.

**4. Benzenemonosulphonic Acid.**—5 c.c. of benzene are brought gradually into contact with 10 c.c. of fuming sulphuric acid. At first heat is developed, and the hydrocarbon dissolves quickly; to complete the reaction, the mixture must be warmed gently. It is then poured into twice its volume of water, common salt added, and the liquid heated until hydrochloric-acid gas is evolved. On cooling, sodium benzenesulphonate separates in crystalline plates.

**5. FRIEDEL and CRAFTS' Reaction.**—1 g. of aluminium chloride is added to 5 c.c. of benzene, and a small quantity of chloroform dropped into the mixture. There is a vigorous evolution of hydrochloric-acid gas, and triphenylmethane is formed.

**6. Formation of Benzene from Calcium Benzoate.**—10 g. of calcium benzoate are mixed with a like weight of soda-lime, and heated in a retort connected with a condenser. Benzene

distils, and can be identified by its odour, by the fact that it floats on water, and by converting it into nitrobenzene with a mixture of concentrated nitric and sulphuric acids in accordance with the method described in 3.

**7. Oxidation of Side-chains.**—1 c.c. of toluene is heated with a solution of potassium permanganate and sodium carbonate. The purple colour is discharged, and manganese dioxide precipitated, in consequence of the oxidation of the side-chain.

## XXIV. MONOHALOGEN COMPOUNDS.

(272 and 273.)

**1. Stability of Monochlorobenzene towards Alcoholic Potash or Soda.**—5 c.c. of monochlorobenzene are heated with 10 c.c. of ten per cent. alcoholic potash or soda for a few minutes, and the liquid diluted with water. The monochlorobenzene is precipitated unchanged as an oily liquid. To prove this, it is separated by means of a tap-funnel, dried by contact with granulated calcium chloride for a few minutes, and its boiling-point determined by the method of **III**, 5. Monochlorobenzene boils at 132°.

After separation of the monochlorobenzene, the aqueous liquid is acidified with nitric acid, and silver nitrate added. It does not become turbid, proving that the caustic alkali has not reacted with the Cl-atoms of the monochlorobenzene.

**2. Saponification of Benzyl Chloride by Caustic Potash or Soda.**—1 c.c. of benzyl chloride is warmed for a short time with 10 c.c. of ten per cent. alcoholic potash or soda, and the mixture diluted with a large excess of water. If the heating has been of sufficient duration, no benzylchloride separates. After acidifying with nitric acid, the solution gives with silver nitrate a heavy precipitate of silver chloride.

**3. Benzyl Iodide.**—A small quantity of benzyl chloride is heated with an alcoholic solution of potassium iodide in a fume-

cupboard. Benzyl iodide is formed, and gives off an extremely irritating odour, productive of tears.

## XXV. MONOHYDRIC PHENOLS.

(274-276.)

**1. Preparation of Phenol from Calcium Salicylate.**—10 g. of calcium salicylate are heated in a retort connected with a condenser. Phenol distils, and can be recognized by its odour, and by the reactions described in 4 and 5.

**2. Preparation of Phenol by Fusion of Sodium Benzenesulphonate with Caustic Soda.**—10 g. of sodium benzenesulphonate, 3 g. of solid caustic soda, and a small quantity of water are heated in an iron dish to the temperature of fusion, the mixture being continually stirred. When cold, it is dissolved in water, the solution poured into a fractionating-flask, and dilute sulphuric acid added slowly. Much sulphur dioxide is evolved, and can be recognized by its characteristic odour. The flask is connected with a condenser, and heated. Phenol distils along with water, and is identified by the methods of 4 and 5.

**3. Sodium Phenoxide.**—1 g. of phenol is agitated with enough water to form an emulsion; on addition of caustic-soda solution, this dissolves, forming sodium phenoxide. When carbon dioxide is passed through the liquid for a considerable time, phenol is liberated, and the mixture rendered turbid.

**4. Tribromophenol.**—Bromine-water is added to a two per cent. aqueous solution of phenol. Tribromophenol is precipitated.

**5. Ferric-chloride Test for Phenol.**—On addition of a drop of ferric-chloride solution to a one per cent. solution of phenol, an intense violet colouration is obtained.

**6. Depression of the Freezing-point of Phenol.**—5 c.c. of phenol are melted in a test-tube by very careful heating over a tiny flame. After introduction of a thermometer, the liquid is

allowed to cool. When crystals begin to form, the mercury ceases falling, and rises, the highest temperature indicated being the freezing-point. For anhydrous phenol, this is  $39^{\circ}$ .

The phenol is again melted, and 1 drop—about 0.05 g.—of water added. The freezing-point is determined as before, and found to be about  $4^{\circ}$  lower.

**7. Action of Nitric Acid on Phenol.**—A cubic centimetre of phenol is added drop by drop to 10 c.c. of nitric acid of specific gravity 1.3, the liquid being continually agitated, and, finally, heated to boiling. On cooling, picric acid is precipitated. When recrystallized from water, it is obtained as yellow, needle-like crystals.

**8. Cresol.**—With bromine-water and ferric chloride respectively, an aqueous solution of cresol gives reactions similar to those obtained with phenol (4 and 5).

## XXVI. MONOAMINO-COMPOUNDS AND THEIR DERIVATIVES.

(282–291.)

**1. Aniline.**—35 c.c. of hydrochloric acid of 1.19 specific gravity are poured into a flask containing 6 g. of nitrobenzene, and 18 g. of tin-powder added in successive small portions. To prevent its contents becoming overheated, the flask is shaken, and cooled with water. The nitrobenzene is reduced to aniline, this combining with the excess of hydrochloric acid to aniline hydrochloride. When all the nitrobenzene has dissolved, and its odour is no longer perceptible, the aniline is set free by caustic potash or soda, and the mixture distilled. The aniline volatilizes with the steam, rendering the distillate turbid.

**2. Neutral Reaction of Aniline.**—A small quantity of aniline is agitated with water. The solution thus prepared neither imparts a colour to phenolphthaleïn, nor turns red litmus blue.

3. **Aniline Salts.**—On addition of an acid, the turbid liquid obtained in 1 becomes clear, a soluble aniline salt being formed. Caustic potash or soda reprecipitates the aniline as an oil.

4. **Tribromoaniline.**—With an aqueous solution of aniline or of one of its salts, bromine-water gives a precipitate of tribromoaniline.

5. **Bleaching-powder Test for Aniline.**—A few drops of aniline are agitated with water, and the solution separated from undissolved amine by passing it through a moist filter. A small quantity of a clear solution of bleaching-powder gives a deep-violet colouration with the filtrate.

6. **Potassium-dichromate Test for Aniline.**—2 or 3 drops of aniline are dissolved in dilute sulphuric acid. On addition of potassium-dichromate solution, a precipitate—green, blue, or black according to the concentration—is obtained. The black precipitate is called *aniline-black*.

7. **Acetanilide.**—A mixture of 9 c.c. of aniline and a like volume of glacial acetic acid is boiled in a flask with a reflux-condenser for several hours. On cooling, crystals of acetanilide (“antifebrine”) are deposited. When recrystallized from a small quantity of alcohol, these melt at 112°.

8. **Carbylamine Reaction.**—Aniline can be proved to be a primary amine by the carbylamine reaction (VII, 2).

9. **Diphenylamine.**—0.1 g. of diphenylamine is dissolved in a small quantity of alcohol, and the solution poured into water. The amine is now suspended in the water in a fine state of division, and can be dissolved by addition of concentrated hydrochloric acid drop by drop to the liquid. On dilution of this solution with water, the diphenylamine is reprecipitated, the hydrochloride undergoing hydrolytic dissociation.

10. **Nitrosodimethylaniline.**—1.4 g. of sodium nitrite dissolved in water is added gradually to a well-cooled solution of 2.4 g. of dimethylaniline in 12.5 g. of twenty per cent. hydrochloric acid. Yellow nitrosodimethylaniline hydrochloride is precipitated. It is collected on a filter, washed with dilute

hydrochloric acid, and purified by crystallization from hot water. The salt is triturated with water, caustic soda is added, and the green nitrosodimethylaniline liberated is dissolved in ether. On distilling the ether, the base is obtained in splendid, yellowish-green leaves. These are boiled with caustic soda, whereby dimethylamine is evolved, and the liquid becomes dark-red owing to the formation of sodium nitrosophenoxide. The dimethylamine can be identified by its characteristic odour, and its alkaline reaction to litmus.

**11. Azobenzene, Hydrazobenzene, and Benzidine Sulphate.**—

A mixture of 2 c.c. of nitrobenzene and 20 c.c. of twenty per cent. alcoholic potash is gently warmed, and small quantities of zinc-dust added. In consequence of the formation of azobenzene, the liquid develops a red colour. On addition of more zinc-dust, the colour is discharged, and hydrazobenzene produced. When the liquid is poured into a quantity of dilute sulphuric acid sufficient to make it strongly acid, nearly insoluble benzidine sulphate is soon precipitated.

**12. Diphenylurea.**—1 g. of urea and 3 g. of aniline are gently boiled in a test-tube for fifteen to thirty minutes, and poured into a dish. On cooling, diphenylurea crystallizes out, the mixture becoming solid. The excess of aniline is removed by treatment with dilute hydrochloric acid, the residue washed with water, and crystallized from alcohol.

## **XXVII. BENZOÏC ACID AND ITS DERIVATIVES.**

(296–298.)

**1. Benzonitrile and Benzoïc Acid.**—10 g. of sodium benzenesulphonate are mixed with a like weight of dried potassium ferrocyanide, and the mixture submitted to dry distillation in a retort connected with a condenser. Benzonitrile and a trace of phenylcarbylamine distil. The isonitrile is decomposed by warming with two drops of concentrated hydrochloric acid.

About 20 c.c. of ten per cent. caustic potash are added, and the mixture is boiled in a flask with a reflux-condenser. Ammonia is evolved, as can be proved by red litmus-paper, while the oily layer of benzonitrile disappears. The flask is cooled, and concentrated hydrochloric acid added slowly; a white, flocculent precipitate of benzoïc acid is deposited.

2. **Benzoïc Acid from Gum-benzoin.**—5 g. of finely-powdered gum-benzoin are mixed with sand, and heated gently in a porcelain dish on a sand-bath for an hour, care being taken to avoid fusion. The dish is covered with a hollow paper-cone, into which the benzoïc acid sublimes.

3. **Volatility of Benzoïc Acid with Steam.**—1 g. of benzoïc acid is heated with water in a fractionating-flask connected with a condenser. The acid volatilizes with the steam, as is proved by the odour and acid reaction of the distillate.

4. **Ethyl Benzoate.**—1 g. of benzoïc acid is warmed with 5 c.c. of absolute alcohol and a few drops of concentrated sulphuric acid. The ethyl benzoate formed is characterized by a peppermint-like odour.

5. **Benzanilide.**—A few cubic centimetres of water are added to 1 c.c. of aniline, and then alternately small quantities of caustic potash and benzoyl chloride drop by drop. The mixture is agitated constantly, care being taken to maintain it alkaline. Finally, the alkaline liquid is agitated till the odour of benzoyl chloride is not perceptible. The white precipitate of benzanilide is collected on a filter, washed with water till this is no longer alkaline, and crystallized from alcohol. M. P. 158°.

6. **Benzamide.**—3 g. of ammonium carbonate are reduced to fine powder in a mortar, and benzoyl chloride added drop by drop, the mixture being stirred continuously with the pestle till the odour of benzoyl chloride is no longer perceptible. It is lixiviated with cold water to remove ammonium chloride and carbonate, and the residue dissolved in a small quantity of hot water. On cooling, benzamide crystallizes out. M. P. 128°.



This substance is tested for by warming with dilute caustic potash. Ammonia is evolved, and addition of hydrochloric acid to the alkaline solution precipitates benzoic acid.

**7. Oxidation of Cinnamic Acid by Potassium Permanganate.**—0.1 g. of cinnamic acid is agitated with water, and several drops of a one per cent. solution of potassium permanganate added. The colour of the solution is discharged, a precipitate of hydrated manganese dioxide formed, and the liquid acquires an odour of benzaldehyde.

## XXVIII. BENZALDEHYDE.

(299.)

**1. Silver-mirror Test.**—2 drops of benzaldehyde are added to an ammoniacal solution of silver nitrate, prepared as described in **X**, 2. Gentle heating in a water-bath produces a silver mirror.

**2. Benzaldehydephenylhydrazone.**—A few drops of benzaldehyde are added to a solution of phenylhydrazine in dilute acetic acid. Benzaldehydephenylhydrazone is precipitated, and by crystallization from alcohol is obtained in large, fine crystals, melting at 152°.

**3. Sulphite Compound of Benzaldehyde.**—A cubic centimetre of benzaldehyde is agitated with a very concentrated solution of sodium hydrogen sulphite. The crystalline sulphite compound is precipitated, and the odour of benzaldehyde ceases to be perceptible. On warming with water, the sulphite derivative is decomposed, and the benzaldehyde liberated.

**4. Action of Alcoholic Potash on Benzaldehyde.**—On mixing 1 c.c. of benzaldehyde with 5 c.c. of a ten per cent. solution of alcoholic potash, heat is developed, and the liquid solidifies owing to the precipitation of potassium benzoate. The crystals are collected on a filter, washed with a small quantity of alcohol,

and dissolved in water. Addition of hydrochloric acid precipitates benzoic acid.

The alcoholic filtrate contains benzyl alcohol (277), which can be identified by evaporating the ethyl alcohol, and carefully adding concentrated sulphuric acid to the residue. The benzyl alcohol resinifies.

**5. Oxidation of Benzaldehyde by Potassium Permanganate.**—

A few drops of benzaldehyde are heated with an aqueous solution of potassium permanganate. Manganese dioxide is precipitated, the aldehyde being oxidized to benzoic acid, which remains dissolved as potassium benzoate. When the odour of benzaldehyde is no longer perceptible, two drops of alcohol are added to reduce the excess of potassium permanganate, and the colourless liquid filtered. On acidifying the filtrate, benzoic acid is precipitated.

**XXIX. DIAZONIUM COMPOUNDS AND AZO-DYES.**

(302–304, and 320–324.)

**1. Benzenediazonium Chloride.**—9.3 g. of aniline are dissolved in about 100 c.c. of hydrochloric acid containing 9.2 g. of HCl. To this solution, maintained between 5° and 10° by the introduction of ice, is added very slowly a concentrated aqueous solution of 7.2 g. of commercial sodium nitrite, the liquid being stirred constantly. The solution of benzenediazonium chloride thus obtained is kept in a vessel surrounded by ice and used for experiments 2 and 3.

**2 Replacement of the N<sub>2</sub>-Group in Benzenediazonium Chloride by Hydroxyl.**—A small quantity of the solution of benzenediazonium chloride is warmed in a fractionating-flask connected with a condenser. When the evolution of nitrogen has ceased the solution is distilled, water and phenol passing over. The latter can be identified by its odour, and by reactions **XXV**, 4 and 5

3. **Diazoaminobenzene.**—Aniline is mixed with ten times its volume of water, and enough hydrochloric acid to give a clear solution. Addition of part of the solution of benzenediazonium chloride prepared in 1 and solid sodium acetate produces a yellow or brown precipitate of diazoaminobenzene.

4. **Aminoazobenzene.**—A small quantity of diazoaminobenzene is warmed gently with about twice its volume of aniline and some solid aniline hydrochloride. Aminoazobenzene is formed. On addition of concentrated hydrochloric acid and solid salt, steel-blue needles of aminoazobenzene hydrochloride are obtained.

5. **Dyeing with Aminoazobenzene.**—An alcoholic solution of aminoazobenzene is diluted with water, and a few drops of dilute hydrochloric acid added. A woollen thread immersed in the liquid for a quarter of an hour is dyed yellow, and the colour cannot be removed by washing with water.

6. **Reduction of Aminoazobenzene.**—A small quantity of aminoazobenzene hydrochloride is brought into contact with tin and hydrochloric acid. It is decolourized, yielding *p*-phenylenediamine and aniline. The mixture is made strongly alkaline with caustic soda, and distilled, using a condenser. The presence of aniline in the distillate can be proved by the bleaching-powder test (XXVI, 5).

7. **Oxidation of Phenylhydrazine by FEHLING's Solution (305).**—A drop of phenylhydrazine on a watch-glass is mixed with a small quantity of concentrated hydrochloric acid. There results phenylhydrazine hydrochloride, nearly insoluble in dilute hydrochloric acid. After pouring-off the excess of hydrochloric acid, a small quantity of the salt is dissolved in water in a test-tube, and FEHLING's solution (XVI, 6) added. Reduction takes place at ordinary temperature, with formation of cuprous oxide.  $\text{Cu}_2\text{O}$ .

**XXX. POLY-SUBSTITUTED DERIVATIVES CONTAINING  
SIMILAR SUBSTITUENTS.**

(310-331.)

**1. Pyrogallol.**—On carefully heating 5 g. of well-dried gallic acid in a retort, carbon dioxide—which can be identified by the lime-water test—is evolved, and pyrogallol sublimes. The latter is dissolved in water, and the solution divided into three parts.

When silver-nitrate solution is added to one, metallic silver is precipitated.

Addition of a drop of ferric chloride to the second produces an intense bluish-black colouration.

The third portion is transferred to a thick-walled test-tube, caustic potash added, the tube closed with a closely-fitting cork or rubber stopper, and the mixture vigorously agitated. The oxygen in the tube is absorbed, the pyrogallol-solution turning brown. On removing the stopper under water, the latter rises in the tube.

**2. Benzoquinone.**—To a drop of aniline in a dish are added a small quantity of potassium-dichromate solution and a drop of concentrated sulphuric acid. The pungent odour of benzoquinone is perceived.

**3. Tests for Catechol, Resorcinol, and Quinol.**—With a drop of ferric chloride, aqueous solutions of catechol and resorcinol give a green and a deep-violet colouration respectively. With bromine-water, resorcinol yields a precipitate of tribromo-resorcinol.

Solutions of catechol and resorcinol are made alkaline with caustic soda. They acquire a dark colour immediately.

Addition of ammonium hydroxide to a solution of quinol turns it red-brown.

**4. *m*-Dinitrobenzene.**—1.5 c.c. of benzene are added drop by drop to a mixture of 5 c.c. of concentrated sulphuric acid

and 5 c.c. of fuming nitric acid, the liquid being agitated thoroughly during the process. The solution is heated for a few minutes, allowed to cool, and poured into water. *m*-Dinitrobenzene is precipitated, and is freed from a small percentage of the *ortho*-compound and traces of the *para*-compound by crystallization from alcohol. M. P. 90°.

**5. Test for Nitrous Acid with *m*-Phenylenediamine.**—To 10 c.c. of a dilute solution of *m*-phenylenediamine are added a drop of a solution of sodium nitrite, and a drop of dilute sulphuric acid. The liquid becomes brown, Bismarck-brown being formed.

**6. Phthalic Anhydride.**—0.1 g. of phthalic acid is heated in a dish, covered with a watch-glass, on a sand-bath. Long needles of phthalic anhydride sublime.

**7. Fluoresceïn.**—Some crystals of phthalic anhydride and a like quantity of resorcinol are heated for a few minutes with 1 c.c. of concentrated sulphuric acid. To prevent the liquid becoming dark-coloured, the heating must not be too prolonged, or the temperature too high. On dissolving the mixture in 100 c.c. of water and adding caustic soda, a beautifully fluorescent, yellowish-green solution containing fluoresceïn is obtained.

**8. Phenolphthaleïn.**—A mixture of like quantities of phthalic anhydride and phenol is warmed with concentrated sulphuric acid, phenolphthaleïn being formed. When this is added to a dilute solution of a caustic alkali, a red colouration is produced.

**9. Red Anion of Phenolphthaleïn.**—A few milligrammes of phenolphthaleïn are dissolved in absolute alcohol containing a trace of calcium hydroxide in suspension; the liquid remains colourless. On dilution with water, the calcium compound of the phthaleïn is ionized, with production of a red colour.

**XXXI. POLY-SUBSTITUTED DERIVATIVES CONTAINING TWO OR MORE DISSIMILAR SUBSTITUENTS.**

(332-351.)

1. *p*-Diazobenzenesulphonic Acid.—1.7 g. of sulphanilic acid,  $\text{NH}_2\cdot\text{C}_6\text{H}_4\cdot\text{SO}_2\text{OH}$  (1:4), are dissolved by heating with 25 c.c. of two per cent. caustic soda. A concentrated aqueous solution of 1 g. of sodium nitrite is added, and the mixture poured into excess of cold, dilute sulphuric acid. After an interval, *p*-diazobenzenesulphonic acid is precipitated as a sand-like, crystalline powder.

2. Nitrophenols.—To 18 c.c. of nitric acid of 1.17 specific gravity are added slowly 3 c.c. of phenol, liquefied by addition of a small quantity of water. During the process, the mixture is cooled, and agitated vigorously. A heavy, black oil separates from the aqueous liquid. After washing with water in a small separating-funnel, the oil is distilled with steam (III, 2). *o*-Nitrophenol distils, and can be identified by its odour, and by its yellow crystals melting at  $44^\circ$ . The residue in the flask contains *p*-nitrophenol.

3. Picric Acid.—On carefully heating 0.1 g. of picric acid in a test-tube, the acid melts and sublimes; more rapid heating causes explosive decomposition, leaving a residue of carbon. At the same time, an odour resembling that of nitrobenzene becomes perceptible.

4. Potassium Picrate.—Caustic potash is added to an alcoholic solution of 0.5 g. of picric acid. Bright-yellow potassium picrate is precipitated, collected on a filter-paper, and dried by exposure to the air. The dry salt is exploded by percussion, and by heating on a platinum or porcelain crucible-lid. *Only a very minute quantity of the salt must be used for this experiment.*

5. Taste of Picric Acid.—0.1 g. of picric acid is dissolved in water; the solution thus obtained has a very bitter taste.

**6. Dyeing with Picric Acid.**—A woollen thread immersed in the liquid is soon dyed bright-yellow.

**7. Isopurpuric Acid.**—An aqueous solution of potassium cyanide is added to one of picric acid. A purple colouration, due to the formation of the potassium salt of isopurpuric acid, is produced.

**8. Chloropicrin.**—0.5 g. of picric acid is warmed carefully with a solution of bleaching-powder. The pungent odour of chloropicrin (151),  $\text{CCl}_3\text{NO}_2$ , becomes perceptible.

**9. Ionization of Picric Acid in Aqueous Solution.**—On warming a small quantity of picric acid with petroleum-ether in a test-tube, a colourless solution is obtained, the acid not being ionized in this solvent. When, however, this colourless solution is agitated with a small quantity of water, the latter acquires the deep-yellow colour characteristic of the anion of picric acid.

**10. Salicylic Acid.**—0.5 g. of salicylic acid is heated gently in a test-tube; it melts, and sublimes. On heating to a higher temperature, it decomposes partly into carbon dioxide and phenol, the characteristic odour of the latter becoming perceptible.

**11. Action of Bromine-water on Salicylic Acid.**—Bromine-water added to a saturated solution of salicylic acid gives a precipitate of the formula  $\text{C}_6\text{H}_2\text{Br}_3\cdot\text{OBr}$ .

**12. Identification of Salicylic Acid and Phenol.**—Ferric chloride is added to alcoholic and aqueous solutions of salicylic acid and phenol respectively. Salicylic acid gives the violet colouration in both solvents, phenol only in water.

**13. Calcium Salicylate.**—0.5 g. of salicylic acid is added to a mixture of calcium-chloride solution and ammonium hydroxide. On heating, calcium salicylate,  $\text{C}_7\text{H}_4\text{O}_3\text{Ca} + \text{H}_2\text{O}$ , is precipitated.

**14. Action of Tannin on Gelatine.**—A solution of tannin is added to one of gelatine. The gelatine is precipitated.

**15. Test for Tannin.**—A dilute solution of tannin is turned dark-violet by a drop of ferric chloride. A piece of oak-bark

or cinchona-bark, an unroasted coffee-bean, and part of a gall-nut are extracted with boiling water in different dishes. The presence of tannin in all these solutions can be proved by the ferric-chloride test.

**16. Action of Tannin on Quinine.**—On addition of a solution of tannin to one of quinine hydrochloride, the alkaloid is precipitated.

**17. Interaction of Albumin and Tannin.**—10 c.c. of milk are freed from casein and fat by the method described in **XVIII**, 21. The presence of albumin in the filtrate can be proved by adding tannin, an insoluble compound of albumin and tannin being precipitated.

**18. Hydrolysis of *p*-Nitraniline Hydrochloride.**—0.5 g. of *p*-nitraniline is dissolved by gentle heating with as small a quantity of concentrated hydrochloric acid as is necessary to effect solution. On addition of water, the yellow nitraniline is reprecipitated, owing to almost complete hydrolytic dissociation of the hydrochloride.

## XXXII. TERPENES AND CAMPHORS.

(358–363.)

**1. Artificial Camphor.**—American or German oil of turpentine is dried by calcium chloride, poured off, and distilled. Dry hydrochloric-acid gas, prepared by the method of **IX**, 15, is led into 10 c.c. of the dry turpentine, the flask being cooled by ice. After some time, transparent crystals of pinene hydrochloride or “artificial camphor,”  $C_{10}H_{16} \cdot HCl$ , are deposited. The mother-liquor is poured off, and the crystals dried by pressing between layers of filter-paper. In odour and appearance pinene hydrochloride resembles camphor.

**2. Volatility of Camphor with Steam.**—A piece of camphor is placed in water in a fractionating-flask connected with a condenser. On heating, the camphor passes over with the steam.



3. **Camphor and Water.**—A piece of camphor thrown upon the surface of water acquires a rotatory motion, due to disparity of the vapour tension for the different crystal faces.

4. **Camphoric Acid.**—2 g. of camphor are heated in a flask with dilute nitric acid for some minutes, and evaporated almost to dryness in a porcelain dish. The residue is diluted with water, made alkaline with caustic soda, and the undissolved portion filtered off. If the filtrate is not too dilute, hydrochloric acid precipitates camphoric acid.

### XXXIII. BENZENE-NUCLEI LINKED TOGETHER BY CARBON.

(364–369.)

1. **Rosolic Acid.**—A mixture of 2 c.c. of phenol, 0.5 g. of oxalic acid, and 5 c.c. of concentrated sulphuric acid is heated in a test-tube. It acquires a red colour. On pouring the liquid into water, and making it alkaline with caustic potash, a dark-red solution is obtained, containing the potassium salt of rosolic acid.

2. **Magenta.**—1 c.c. of aniline is heated in a test-tube with 1 g. of *p*-toluidine and 0.5 g. of mercuric chloride, magenta being formed. On pouring the liquid into water containing a small quantity of hydrochloric acid, a deep-red solution is produced.

3. **Action of Concentrated Hydrochloric Acid on a Solution of Magenta.**—Concentrated hydrochloric acid is added to part of the solution obtained in 2. The liquid becomes yellow, owing to the formation of the hydrochloride of the rosaniline base containing 3HCl. When this is poured into a large quantity of water, the red colour is restored.

4. **Colour-base.**—Excess of ammonium hydroxide or caustic potash is added to another portion of the magenta solution. The colour-base is formed, and the liquid decolourized.

5. **Leuco-base.**—A third portion of the magenta solution is treated with zinc and hydrochloric acid, without the application of heat. The leuco-base is formed, and the colour discharged.

#### XXXIV. CONDENSED BENZENE-NUCLEI.

(370-385.)

1. **Action of Heat on Naphthalene.**—0.5 g. of naphthalene is heated in a test-tube. It melts, and sublimes readily.

2. **Naphthalene Picrate.**—3 c.c. of a concentrated ether solution of picric acid are mixed with a like volume of a concentrated solution of naphthalene in that solvent. A yellow, crystalline precipitate of naphthalene picrate is produced.

3. **Naphthalenemonosulphonic Acids.**—A mixture of 0.5 g. of naphthalene and 2 c.c. of concentrated sulphuric acid is heated in a test-tube for a few minutes, allowed to cool, and poured into water. On treatment with barium carbonate by the method of VI, 2, the presence of the dissolved sulphonic acids is proved.

4.  **$\alpha$ -Nitronaphthalene.**—1 g. of naphthalene is brought into contact with 5 c.c. of concentrated nitric acid, and the mixture poured into water. The precipitated yellow  $\alpha$ -nitronaphthalene is crystallized from a small quantity of alcohol, being obtained in yellow needles, melting at  $61^{\circ}$ .

5. **Crude Naphthol.**—0.5 g. of naphthol is agitated with water; only a small quantity dissolves. On addition of caustic potash or soda, a solution is obtained, from which carbon dioxide reprecipitates the naphthol.

6. **Martius' Yellow.**—1 g. of  $\alpha$ -naphthol is dissolved in 3 c.c. of concentrated sulphuric acid, and the solution poured into 3 c.c. of concentrated nitric acid. When this mixture is diluted with water, dinitro- $\alpha$ -naphthol is precipitated. It is filtered off, washed, transferred to a vessel containing water, and dissolved by addition of a small quantity of caustic soda, with

formation of the sodium salt, Martius' yellow. A woollen thread dipped into this solution becomes dyed deep-yellow.

**7. Naphthylamines.**—0.5 g. of  $\alpha$ -naphthylamine is dissolved in dilute hydrochloric acid. With ferric chloride this solution gives a blue precipitate. A similar solution of pure  $\beta$ -naphthylamine does not react thus.

**8. Congo-red.**—A few centigrammes of congo-red are placed in water, and a drop of concentrated hydrochloric acid added. The liberated acid turns the liquid blue; addition of an alkali restores the red colour.

**9. Naphthionic Acid.**—A mixture of 1 g. of  $\alpha$ -naphthylamine and 3 c.c. of concentrated sulphuric acid is heated in a test-tube for a few minutes, and poured into water. On making the liquid alkaline with caustic soda, it exhibits an intense reddish-blue fluorescence, resulting from the formation of sodium naphthionate.

**10. Oxidation of Anthracene by Chromic Acid.**—Small quantities of an acetic-acid solution of chromic acid are added to a solution of 3 g. of anthracene in this solvent, until the energetic reaction has ceased. The liquid is poured into water, and the precipitated anthraquinone collected on a filter.

**11. Test for Anthraquinone.**—A few centigrammes of anthraquinone are heated in a test-tube with zinc-dust and caustic soda, a deep blood-red solution of oxanthranol being formed. On agitating this solution with air, the colour is discharged.

**12. Alizarin.**—3 g. of anthraquinone are dissolved in 10 c.c. of fuming sulphuric acid, and the solution heated till a drop gives no turbidity with water. After cooling, the solution of anthraquinonesulphonic acid is poured into 100 c.c. of water, and neutralized by addition of solid sodium carbonate. The precipitated sodium sulphonate is collected on a filter, dried on a porous plate, and carefully heated to fusion on an iron dish with caustic potash and a small quantity of potassium chlorate. When cold, the product is dissolved in water, the solution being

coloured violet-red by the potassium salt of alizarin. Dilute sulphuric acid precipitates red alizarin.

### XXXV. HETEROCYCLIC COMPOUNDS.

(386-394.)

1. **Pyridine.**—Some drops of pyridine are added to a few cubic centimetres of water, the base dissolving completely. The solution has an alkaline reaction.

2. **Action of Pyridine on Ferric Chloride.**—The aqueous solution of pyridine gives with one of ferric chloride a precipitate of ferric hydroxide.

3. **Action of Pyridine on Mercuric Chloride.**—A solution of mercuric chloride added to a pyridine solution precipitates a white, crystalline compound of pyridine and mercuric chloride.

4. **Test for Pyridine.**—Hydrochloroplatinic acid,  $\text{H}_2\text{PtCl}_6$ , is added to a small quantity of a solution of pyridine; no precipitate is formed. On boiling the mixture for a short time, a yellow powder of the formula  $\text{PtCl}_4(\text{C}_5\text{H}_5\text{N})_2$  is deposited. This is a characteristic test for pyridine.

5. **Action of the Alkaloid-reagents on Pyridine.**—The alkaloid-reagents (401)—among them tannin, phosphomolybdic acid, and picric acid—precipitate pyridine from solution.

6. **Stability of Pyridine towards VON BAEYER's Reagent.**—A solution of potassium permanganate and sodium carbonate is added to one of pyridine. The violet-red colour is not altered.

7. **Stability of Pyridine towards Oxidizing-agents.**—A solution of pyridine is heated with sodium or potassium dichromate and concentrated sulphuric acid. The colour of the solution undergoes no change.

8. **Pyrrole-red.**—Water is added to a small quantity of "Dippel's oil" (386) in a test-tube, and the mixture boiled. A wood-splint moistened with concentrated hydrochloric acid becomes coloured red by the vapour, pyrrole-red being formed.

**9. Indophenin Reaction.**—A cubic centimetre of crude benzene and a like volume of concentrated sulphuric acid are brought into contact with a fragment of isatin. In presence of thiophen, a blue colouration is produced.

10 c.c. of crude benzene are agitated repeatedly with warm, concentrated sulphuric acid, about 2 c.c. being used for each operation. The benzene is separated, and tested by the indophenin reaction. Either the blue colouration is not produced, or it is much less pronounced than in the first experiment.

**10. Tests for Antipyrine.**—A solution of antipyrine is turned red by ferric chloride, bluish-green by potassium or sodium nitrite and acetic acid.

## XXXVI. CONDENSATION-PRODUCTS OF BENZENE AND HETEROCYCLIC NUCLEI.

(395–399.)

**1. SKRAUP'S Synthesis of Quinoline.**—A mixture of 4 c.c. of aniline, 12 c.c. of glycerol, 2.5 c.c. of nitrobenzene, and 6 c.c. of sulphuric acid is heated carefully in a flask till the reaction begins, the burner being then removed. When it has moderated, the heating is resumed, and continued for five or ten minutes. The liquid is cooled, poured into water, and distilled with steam (III, 2) after addition of excess of caustic soda. The turbidity of the distillate is caused by the presence of minute drops of quinoline. The characteristic odour of the base is perceived.

**2. Quinoline Hydrochloride.**—On addition of hydrochloric acid to the distillate obtained in 1. the liquid becomes clear, soluble quinoline hydrochloride being formed. Caustic soda or potash reprecipitates the quinoline in oily drops.

**3. Quinoline Picrate.**—With a solution of quinoline hydrochloride, a saturated, aqueous solution of picric acid gives a yellow, amorphous precipitate of quinoline picrate.

4. **Quinoline Dichromate.**—With quinoline salts, potassium dichromate gives a yellow, crystalline precipitate of quinoline dichromate,  $(C_9H_7N)_2H_2Cr_2O_7$ .

5. **Volatility of Indigo.**—On heating 0.1 g. of indigo in a test-tube, a violet vapour is obtained.

6. **Solubility of Indigo in Nitrobenzene.**—0.1 g. of indigo is heated with a small quantity of nitrobenzene. It dissolves, and, on cooling, crystallizes.

7. **Indigosulphonic Acid.**—0.1 g. of indigo is dissolved in 1 c.c. of fuming sulphuric acid. Indigosulphonic acid is formed, so that the indigo is not reprecipitated when the solution is poured into water.

8. **Oxidation of Indigo to Isatin.**—The solution of indigo-sulphonic acid obtained in 7 is warmed with a small quantity of concentrated nitric acid. It is decolourized, and isatin formed.

9. **"Indigo-vatting."**—0.1 g. of powdered indigo is heated with a solution of sodium hyposulphite,  $Na_2S_2O_4$  ("Inorganic Chemistry," 83). Sodium thiosulphate, miscalled "sodium hyposulphite," must not be used. A strip of linen or cotton is immersed in the solution of indigo-white, and hung up to dry. The oxygen of the atmosphere oxidizes the indigo-white to indigo-blue.

## XXXVII. ALKALOIDS.

(400–411.)

1. **Alkaloid-reagents.**—A solution of an alkaloid, such as quinine hydrochloride or sulphate, is tested with solutions of the ordinary alkaloid-reagents; for example, tannin, phosphomolybdic acid, mercuric potassium iodide, and a solution of iodine in one of potassium iodide. With each a precipitate is formed.

2. **Nicotine.**—10 g. of tobacco are boiled with 100 c.c. of water containing a small quantity of sulphuric acid. After

filtering, the filtrate is rendered alkaline, and distilled. The distillate contains nicotine, and yields precipitates with platinum chloride, mercuric chloride, and a potassium-iodide solution of iodine.

**3. Fluorescence of Quinine-sulphate Solution.**—0.1 g. of quinine sulphate is dissolved in water containing sulphuric acid. The solution exhibits a blue fluorescence.

**4. Action of Chlorine on Quinine Salts.**—Chlorine-water is added to a solution of a quinine salt until the liquid smells strongly of the gas. On addition of ammonium hydroxide, an emerald-green colouration is produced.

**5. Test for Strychnine.**—A crystal of strychnine nitrate is placed in a porcelain dish, and a few drops of concentrated sulphuric acid added. A small crystal of potassium dichromate produces with this liquid a very intense bluish-violet colour.

**6. Test for Brucine.**—A small quantity of brucine yields a red colouration with concentrated nitric acid; on the application of gentle heat, this changes to yellow. Dilution with water, and addition of ammonium sulphide, renders the yellow solution violet.

### XXXVIII. ALBUMINS.

(412-418.)

**1. Detection of Nitrogen and Sulphur in the Albumins.**—A few cubic centimetres of a solution of albumin—prepared by dissolving white-of-egg in five times its volume of water—is heated with caustic potash. Ammonia is evolved, and can be detected by the aid of a moist strip of red litmus-paper.

The liquid is diluted with water, and lead acetate added. The potassium sulphide formed in the last experiment reacts with the lead salt, precipitating black lead sulphide.

**2. "Salting-out" Albumin with Ammonium Sulphate.**—Solid ammonium sulphate is added to 20 c.c. of the albumin solution. The albumin is precipitated.

3. **Coagulation of Albumin by Alcohol.**—Strong alcohol added to a solution of albumin gives a precipitate of coagulated albumin. A similar precipitate is formed when an aqueous solution of albumin is boiled. Coagulated albumin is soluble in dilute caustic potash, in concentrated hydrochloric acid, and concentrated sulphuric acid.

4. **Coagulation of Albumin by Nitric Acid.**—Dilute nitric acid is added to an albumin solution prepared by the method of 1. The albumin is precipitated.

5. **Biuret Reaction.**—A few drops of copper-sulphate solution are added to 5 c.c. of a solution of albumin. Careful addition of dilute caustic potash to the mixture precipitates copper albuminate. Excess of caustic potash redissolves the precipitate, producing a violet-red colouration.

6. **MILLON'S Reagent.**—On boiling an albumin solution with MILLON'S reagent—a solution of mercuric nitrate containing nitrous acid—a red, coagulated mass is obtained.

7. **Xanthoprotein Reaction.**—An albumin solution warmed with dilute nitric acid is coagulated, with production of a yellow colouration.

8. **ADAMKIEWICZ'S Reaction.**—With concentrated sulphuric acid a solution of albumin in glacial acetic acid yields a violet colouration, due to the presence in the mixture of a small proportion of glyoxylic acid.

9. **Decomposition-products of Ceratin.**—A feather is heated with concentrated caustic potash. It dissolves, and the solution thus obtained gives the reactions for nitrogen and sulphur, described in 1.





# INDEX.

The principal references are in old-style figures.

- A.
- Acetal, 20.
  - Acetaldehyde, 20, 21.
  - Acetamide, 2, 12.
  - Acetanilide, 51.
  - Acetate, Basic ferric, 17.
  - Calcium, 21.
  - Ethyl, 19, 20, 40.
  - Ferric, 17.
  - Lead, 4, 5, 18, 28, 68.
  - Potassium, 36.
  - Silver, 17.
  - Sodium, 7, 17, 56.
  - Acetic acid, 10, 16-18, 19, 22, 25, 27, 37, 51.
  - Test for, 17, 22.
  - Acetone, 21, 22.
  - Test for, 21.
  - Acetylene, 23, 24.
  - Copper, 23.
  - Silver, 23.
  - Acid, Acetic, 10, 16-18, 19, 22, 25, 27, 37, 51.
  - Amalic, 46.
  - Anthraquinonesulphonic, 64.
  - Benzenemonosulphonic, 47.
  - Benzoic, 53, 54, 55.
  - n-Butyric, 18.
  - Camphoric, 62.
  - Carbamic, 45.
  - Carbolic. See *phenol*.
  - $\alpha$ -Chloropropionic, 31.
  - Cinnamic, 54.
  - Citric, 32.
  - Cyanic, 42.
  - Cyanuric, 45.
  - p-Diazobenzenesulphonic, 59.
  - Ethylsulphuric, 10, 11.
  - Acid, Ferrocyanic, 41.
  - Formic, 15, 16, 17, 26, 30, 31, 33.
  - Gallic, 57.
  - Glucosesulphuric, 35.
  - Glyoxylic, 69.
  - Hydrocyanic, 40, 41.
  - Indigosulphonic, 67.
  - Isopurpuric, 60.
  - Lactic, 30, 31.
  - Lævulinic, 35.
  - Methylnitrolic, 14.
  - Mucic, 36, 37.
  - Naphthionic, 64.
  - Oleic, 24.
  - Oxalic, 7, 15, 26, 27-29, 44, 62.
  - Phthalic, 58.
  - Picric, 50, 59, 60, 63, 65-67.
  - Propionic, 15.
  - Racemic, 32.
  - Rosolic, 62.
  - Salicylic, 6, 60.
  - Succinic, 30.
  - Sulphanilic, 59.
  - Tartaric, 31, 32.
  - Uric, 46.
  - Xanthic, 43.
  - Acids, Alcohol-. See *acids, hy-droxy-*.
  - $C_nH_{2n}O_2$ , Saturated, 15-20.
  - Higher fatty, 18, 19.
  - Hydroxy-, 30-32.
  - Monobasic unsaturated, 24, 25.
  - Naphthalenemonosulphonic, 63.
  - Saturated dibasic, 27-30.
  - Volatile fatty, 18.
  - Acrolein, 26.
  - ADAMKIEWICZ's reaction, 69.
  - Albumin, 2, 3, 21, 61, 68, 69.

Albuminate, Copper, 69.  
 Alcohol-acids. See *acids, hydroxy-*.  
 Alcohol, Allyl, 26.  
   Benzyl, 55.  
   Ethyl, 5, 9, 10, 11, 12, 17-20, 22, 25, 26, 29, 43, 53, 69.  
   Methyl, 29.  
   Test for ethyl, 26.  
     water in, 9, 10.  
 Alcohols, Aldehyde-. See *sugars*.  
    $C_nH_{2n+1}OH$ , 9, 10.  
   Ketone-. See *sugars*.  
 Aldehyde-alcohols. See *sugars*.  
   -resin, 20.  
 Aldehydes, 20, 21.  
 Alizarin, 64, 65.  
 Alkaloid-reagents, 65, 67.  
 Alkaloids, 67, 68.  
 Alkyl halides, 10.  
 Allotropic modifications of carbon, 4, 5.  
 Alloxantine, 46.  
 Allyl alcohol, 26.  
 Almond oil, 24, 25.  
 Amalic acid, 46.  
 Amines, 12-14, 50-52.  
   Test for primary, 12.  
 Aminoazobenzene, 56.  
   hydrochloride, 56.  
 Ammonium copper cyanurate, 45.  
   cyanate, 44.  
   dithiocarbamate, 45.  
   formate, 41.  
   oxalate, 28.  
   purpurate, 46.  
   thiocyanate, 3, 45.  
   urate, 46.  
 Amylene, 23.  
 Amyloid, 39.  
 Analysis of carbon compounds,  
   Qualitative, 1-4.  
 Aniline, 34, 40, 50, 51, 52, 53, 55-57, 66.  
   -black, 51.  
   hydrochloride, 56.  
 Anthracene, 64.  
 Anthraquinone, 64.  
   -sulphonate, Sodium, 64.  
   -sulphonic acid, 64.  
 Antifebrine. See *acetanilide*.  
 Antipyrine, 66.  
 Artificial camphor, 61.

Azobenzene, 52.

## B.

BAEYER'S test for the double bond,  
   von, 23, 24, 47, 65.  
 Barium alkoxide of starch, 38.  
   ethylsulphate, 11.  
   glucosesulphate, 35.  
   succinate, 30.  
   trithiocarbonate, 43.  
 BAUMANN and SCHOTTEN'S test for  
   hydroxyl-groups, 27.  
 BEILSTEIN'S test, 2, 3, 10, 31.  
 Benzaldehyde, 54, 55.  
   -phenylhydrazone, 54.  
 Benzamide, 53.  
 Benzanilide, 53.  
 Benzene, 7, 47, 48, 57, 66.  
   -diazonium chloride, 55, 56.  
   -monosulphonic acid, 47.  
   -sulphonate, Sodium, 47, 49, 52.  
 Benzidine sulphate, 52.  
 Benzoate, Calcium, 47.  
   Ethyl, 53.  
   Potassium, 54, 55.  
 Benzoic acid, 53, 54, 55.  
 Benzonitrile, 52, 53.  
 Benzoquinone, 57.  
 Benzoyl chloride, 27, 53.  
 Benzyl alcohol, 55.  
   chloride, 48.  
   iodide, 48, 49.  
 Bismarck-brown, 58.  
 Biuret, 45.  
   reaction, 45, 69.  
 Boiling-point, Determination of, 7.  
 Bone-charcoal, 4, 5.  
 Bran, 34.  
 Bromlauge, 44.  
 Brucine, 68.  
 BUNSEN, 44.  
 Butter, 18.  
 Butyric acid, *n*-, 18.

## C.

Cacodyl oxide, 17.  
   test, 16, 17.  
 Calcium acetate, 21.  
   alkoxide of *D*-glucose, 35.  
   benzoate, 47.  
   carbamate, 45.

- Calcium carbide, 23.  
   citrate, 32.  
   lactate, 31.  
   oxalate, 27, 28.  
   -oxide test, 3.  
   potassium ferrocyanide, 41.  
   racemate, 32.  
   saccharate, 37.  
   salicylate, 49, 60.  
   tartrate, 32.  
 Camphor, 61, 62.  
   Artificial, 61.  
 Camphoric acid, 62.  
 Camphors, 61, 62.  
 Cane-sugar. See *sucrose*.  
 Caramel, 37.  
 Carbamate, Calcium, 45.  
 Carbamic acid, 45.  
 Carbide, Calcium, 23.  
 Carboic acid. See *phenol*.  
 Carbon, Allotropic modifications of,  
   4, 5.  
   Detection of, 1, 2.  
   disulphide, 12, 43, 45.  
   monoxide, 28.  
   tetrachloride, 8.  
 Carbonization, 1.  
 Carbylamine, Ethyl-, 15.  
   Methyl-, 12.  
   reaction, 12, 51.  
 Carbylamines, 12, 14, 15.  
 Casein, 37, 61.  
 Catechol, 57.  
 Cellulose, 39, 40.  
   Nitrates of, 39, 40.  
 Ceratin, 69.  
 Charcoal, Bone-, 4, 5.  
   Wood-, 4.  
 Chloral, 33.  
   hydrate, 33.  
 Chloride, Benzyl, 48.  
 Chloroform, 3, 8, 25, 26, 33, 47.  
 Chloropierin, 60.  
 Chloropropionic acid,  $\alpha$ -, 31.  
 Cinchona-bark, 61.  
 Cinnamic acid, 54.  
 Citrate, Calcium, 32.  
 Citric acid, 32.  
 Coagulation of albumin, 21, 69.  
 Coal-gas, 1, 23.  
 Coffee-beans, 61.  
 Collodion, 40.  
 Colour-base of magenta, 62.  
 Congo-red, 64.  
 Copper acetylene, 23.  
   albuminate, 69.  
   alkoxide of *d*-glucose, 35.  
   ammonium cyanurate, 43.  
   oxalate, 28.  
 CRAFTS. See FRIEDEL.  
 Cresol, 50.  
 Crystallization, 7.  
 Cupric xanthate, 43.  
 Cuprous xanthate, 43.  
 Cyanate, Ammonium, 44.  
   Potassium, 42, 44.  
 Cyanic acid, 42.  
 Cyanide, Potassium, 26, 40, 41, 42,  
   60.  
   silver, 40.  
   Silver, 40, 41.  
 Cyanurate, Copper ammonium, 45.  
 Cyanuric acid, 45.
- D.
- Detection of carbon, 1, 2.  
   halogens, 2, 3.  
   hydrogen, 1, 2.  
   nitrogen, 2.  
   sulphur, 3, 4.  
 Dextrin, 38.  
 Diazo-aminobenzene, 56.  
   -benzenesulphonic acid, *p*-, 59.  
 Dibasic acids, Saturated, 27-30.  
 Diethyl-amine hydrochloride, 13.  
   -nitrosamine, 13.  
   oxalate, 29.  
 Dimethyl-amine, 14, 52.  
   -aniline, 51.  
   oxalate, 29.  
 Dinitro-benzene, *m*-, 57, 58.  
   *o*-, 58.  
   *p*-, 58.  
   - $\alpha$ -naphthol, 63.  
 Dioses, 37, 38.  
 Diphenyl-amine, 51.  
   hydrochloride, 51.  
   -urea, 52.  
 Dippel's oil, 65.  
 Distillation, Fractional, 5.  
   Steam, 5, 6.  
 Dithiocarbamate, Ammonium, 45.  
 Dyeing, 56, 60, 64, 67.

## E.

- Elaïdic transformation, 24.  
 Esters, 10, 11, 18-20.  
 Ether, 6, 11, 12.  
 Ethers, 11, 12.  
 Ethoxide, Sodium, 9, 14.  
 Ethyl acetate, 19, 20, 40.  
   alcohol, 5, 9, 10, 11, 12, 17-20,  
     22, 25, 26, 29, 43, 53, 69.  
   Test for, 26.  
   -amine hydrochloride, 13.  
   benzoate, 53.  
   -carbylamine, 15.  
   chloride, 10.  
   lactate, 31.  
   -mercaptan, 12.  
   nitrite, 13.  
   -sulphate, Barium, 11.  
     Potassium, 12, 14, 31.  
   -sulphuric acid, 10, 11.  
 Ethylene, 22, 23.  
   bromide, 23.  
 Extraction with solvents, 6.

## F.

- Fatty acids, Higher, 18, 19.  
   Volatile, 18.  
 FEHLING'S solution, 31, 32, 34, 37,  
   38, 56.  
 Ferric acetate, 17.  
   Basic, 17.  
   succinate, Basic, 30.  
   thiocyanate, 45.  
 Ferricyanide, Potassium, 41, 42.  
 Ferrocyanic acid, 41.  
 Ferrocyanide, Potassium, 14, 40, 41,  
   42, 52.  
   calcium, 41.  
 Fluoresceïn, 58.  
 Formaldehyde, 21.  
 "Formalin," 21.  
 Formate, Mercuric, 15, 16.  
   Mercurous, 16.  
   Potassium, 25, 27.  
   Silver, 16.  
   Sodium, 27.  
 Formic acid, 15, 16, 17, 26, 30, 31,  
   33.  
 Fractional distillation, 5.  
 FRIEDEL and CRAFTS' reaction, 47.  
 Fructose, *d*-, 36.

- Furfuraldehyde, 34, 35.  
   -hydrazone, 35.  
   test, 34, 35.  
 Fusel-oil, 9.

## G.

- Galactose, *d*-, 36, 37.  
 Gallic acid, 57.  
 Gall-nuts, 61.  
 Gelatine, 21, 60.  
 Glucosazone, 34.  
 Glucose, *d*-, 33, 34, 35, 36, 38.  
   -sulphate, Barium, 35.  
   -sulphuric acid, 35.  
 Glycerol, 15, 18, 26, 27, 34, 66.  
 Glycerose, 34.  
 Glyceryl oleate, 24.  
   tribenzoate, 27.  
 Glyoxylic acid, 69.  
 Graphite, 4.  
 Gum-benzoin, 53.  
 Guncotton, 40.

## H.

- Halogens, Detection of, 2, 3.  
 Heterocyclic compounds, 65, 66.  
 Hexodioses, 37, 38.  
 Hexoses, 35, 36.  
   Hydrochloric-acid test for, 35.  
 "Humus substances," 35.  
 Hydrazobenzene, 52.  
 Hydrocarbons, Saturated, 7-9.  
   Unsaturated, 22-24.  
 Hydrocyanic acid, 40, 41.  
 Hydrogen, Detection of, 1, 2.  
 Hydrolysis of nitriles, 15.  
 Hydroxy-acids, 30-32.  
 Hydroxyl-groups, Test for, 27, 31.

## I.

- Indigo, 67.  
   -sulphonic acid, 67.  
   -vatting, 67.  
 Indophenin reaction, 66.  
 Iodide, Benzyl, 48, 49.  
 Iodoform, 26.  
   test, 13, 26.  
 Iron ammonium tartrate, 31.  
 Isatin, 66, 67.  
 Isonitriles, 12, 14, 15.

Isopurpurate, Potassium, 60.  
Isopurpuric acid, 60.

## K.

Ketone-alcohols. See *sugars*.  
Ketones, 21, 22.  
KJELDAHL's method, 2.  
KNOP, 44.

## L.

Laboratory methods, 5-7.  
Lactate, Calcium, 31.  
Ethyl, 31.  
Lactic acid, 30-32.  
Lactosazone, 38.  
Lactose, 36, 37, 38.  
Lævulinic acid, 35.  
LASSAIGNE's test for nitrogen, 2, 26.  
Lead acetate, 4, 5, 18, 28.  
oleate, 25.  
oxalate, 28.  
"Lead-plaster," 25.  
Lemons, 32.  
Leuco-base of magenta, 63.  
LIEBIG, 44.  
Lignin, Test for, 40.  
Linseed oil, 43.  
Litmus, 50.

## M.

Magenta, 4, 21, 62, 63.  
Martius' yellow, 63, 64.  
Melting-point, Determination of, 6, 7.  
Mercaptan, Ethyl-, 12.  
Mercuric formate, 15, 16.  
Mercurous formate, 16.  
Methane, 7, 8.  
Methyl alcohol, 29.  
-amine, 12, 14.  
-carbylamine, 12.  
-mustard-oil, 12.  
-nitrolic acid, 14.  
Method, KJELDAHL's, 2.  
Methods, Laboratory, 5-7.  
Methylene chloride, 8.  
Milk, 37, 61.  
MILLON's reagent, 69.  
Monobasic unsaturated acids, 24, 25.

Monochlorobenzene, 48.  
Monoses, 33-36.  
Mucate, Potassium, 36.  
Mucic acid, 36, 37.  
Murexide, 46.  
test, 46.  
Mustard-oil, Methyl-, 12.  
reaction, 12.

## N.

Naphthalene, 6, 7, 63.  
-monosulphonic acids, 63.  
picrate, 63.  
Naphthionate, Sodium, 64.  
Naphthionic acid, 64.  
Naphthol, 63.  
Naphthylamine,  $\alpha$ -, 64.  
 $\beta$ -, 64.  
Nicotine, 67, 68.  
Nitriline, *p*-, 61.  
hydrochloride, *p*-, 61.  
Nitrate, Urea, 44.  
Nitriles, 14, 15.  
Hydrolysis of, 15.  
Nitrite, Ethyl, 13.  
Nitro-benzene, 47, 48, 50, 52, 66, 67.  
-compounds, 14, 47.  
-methane, 14.  
Sodium, 14.  
-naphthalene,  $\alpha$ -, 63.  
-phenol, *o*-, 59.  
*p*-, 59.  
-prusside test, 4.  
Nitrogen, Detection of, 2.  
Nitrolic-acid reaction, 14.  
Nitrosamine, Diethyl-, 13.  
Nitrosamines, 13.  
Nitroso-dimethylaniline, 51, 52.  
hydrochloride, 51, 52.  
-phenoxide, Sodium, 52.  
Nitrous-acid test, 13.  
Nitrous acid, Test for, 58.

## O.

Oil. Almond, 24, 25.  
Dippel's, 65.  
Linseed, 43.  
Turpentine, 61.  
Oleate, Glyceryl, 24.  
Lead, 25.  
Sodium, 24.

Olefines, 22, 23.  
 Oleic acid, 24.  
 Osazones, 34.  
 Oxalate, Ammonium, 28.  
   Calcium, 27, 28.  
   Copper, 28, 29.  
     ammonium, 29.  
   Diethyl, 29.  
   Dimethyl, 29.  
   Lead, 28.  
   Potassium, 27.  
     ferric, 29.  
   Sodium, 28.  
   Urea, 44.  
 Oxalates, Complex, 29.  
 Oxalic acid, 7, 15, 26, 27-29, 44, 62.  
 Oxamide, 29, 30.  
 Oxanthranol, 64.  
 Oxidation, 1, 3, 10, 16-18, 22.

## P.

Paper, 40.  
 Paraffin-wax, 8.  
 Parchment-paper, 39.  
 Pentoses, 34, 35.  
 Petroleum, 5, 6, 8.  
 Phenol, 49, 50, 55, 58-60, 62.  
   -phthalein, 50, 58.  
 Phenoxide, Sodium, 49.  
 Phenyl-carbylamine, 52.  
   -hydrazine, 34, 35, 37, 54, 56.  
   hydrochloride, 56.  
 Phenylenediamine, *m*-, 58.  
   *p*-, 56.  
 Phthalic acid, 58.  
   anhydride, 58.  
 Picrate, Naphthalene, 63.  
   Potassium, 59.  
   Quinoline, 66.  
 Picric acid, 50, 59, 60, 63, 65-67.  
 Pinene hydrochloride, 61.  
 Polyoses, 38-40.  
 Potassium acetate, 36.  
   benzoate, 54, 55.  
   calcium ferrocyanide, 41.  
   cyanate, 42, 44.  
   cyanide, 26, 40, 41, 42, 60.  
   ethylsulphate, 12, 14, 31.  
   ferricyanide, 41, 42.  
   ferrocyanide, 14, 40, 41, 42, 52.  
   formate, 25, 27.

Potassium hydrogen saccharate, 36.  
   tartrate, 31, 32.  
   isopurpurate, 60.  
   mucate, 36.  
   oxalate, 27.  
   picrate, 59.  
   propionate, 15.  
   rosolate, 62.  
   silver cyanide, 40.  
   tartrate, 31.  
   thiocyanate, 42.  
   urate, Di-, 46.  
   xanthate, 43.  
 Potato-starch, 39.  
 Propionate, Potassium, 15.  
 Propionic acid, 15.  
 Propionitrile, 15.  
 Prussian-blue test, 2, 40-42.  
 Purpurate, Ammonium, 46.  
 Pyridine, 65.  
 Pyrogallol, 57.  
 Pyrrole-red, 65.

## Q.

Qualitative analysis of carbon compounds, 1-4.  
 Quinine, 61, 68.  
   hydrochloride, 61, 67.  
   sulphate, 67, 68.  
 Quinol, 57.  
 Quinoline, 66.  
   dichromate, 67.  
   hydrochloride, 66.  
   picrate, 66.

## R.

Racemate, Calcium, 32.  
 Racemic acid, 32.  
 Reaction, ADAMKIEWICZ's, 69.  
   Biuret, 45, 69.  
   Carbylamine, 12, 51.  
   FRIEDEL and CRAFTS', 47.  
   Indophenin, 66.  
   Nitrolic-acid, 14.  
   SCHIFF's, 21.  
   Xanthoprotein, 69.  
 Reagent, MILLON's, 69.  
   SCHIFF's, 21.  
   SCHWEITZER's, 39.  
 Reagents, Alkaloid-, 65, 67.  
 Rectified spirit, 5, 10.

Resin, Aldehyde-, 20.  
 Resorcinol, 36, 57, 58.  
 Rosolate, Potassium, 62.  
 Rosolic acid, 62.

## S.

Saccharate, Calcium, 37.  
     Potassium hydrogen, 36.  
 Salicylate, Calcium, 49, 60.  
 Salicylic acid, 6, 60.  
 Salting-out, 68.  
 "Salt of sorrel," 29.  
 "Sand-sugar," See *lactose*.  
 Saponification, 18, 19, 24.  
 Saturated acids,  $C_nH_{2n}O_2$ , 18-20.  
     dibasic acids, 27-30.  
     hydrocarbons, 7-9.  
 SCHIFF's reaction, 21.  
     reagent, 21.  
 SCHOTTEN's test for hydroxyl-  
     groups, BAUMANN and, 27.  
 SCHWEITZER's reagent, 39.  
 Silver acetate, 17.  
     acetylene, 23.  
     cyanide, 40, 41.  
     formate, 16.  
     -mirror test, 20, 30, 33, 54.  
     potassium cyanide, 40.  
     thiocyanate, 42, 43.  
 SKRAUP's synthesis, 66.  
 Smokeless powder, 40.  
 Soap, 18, 19.  
 Sodium acetate, 7, 17, 56.  
     anthraquinonesulphonate, 64.  
     benzenesulphonate, 47, 49, 52.  
     ethoxide, 9, 14.  
     formate, 27.  
     naphthionate, 64.  
     nitromethane, 14.  
     nitrosophenoxide, 52.  
     oleate, 24.  
     oxalate, 28.  
     phenoxide, 49.  
 Solvents, Extraction with, 6.  
 Spirit, Rectified, 5, 10.  
 Starch, 38, 39.  
     Barium alkoxide of, 38.  
     -paste, 38.  
     Potato-, 39.  
     Test for, 38.  
 Steam distillation, 5, 6.

Strychnine, 68.  
     nitrate, 68.  
 Succinate, Barium, 30.  
     Basic ferric, 30.  
 Succinic acid, 30.  
 Succinimide, 30.  
 Sucrose, 1, 34, 37.  
 Sugar. See *sucrose*.  
     Cane-. See *sucrose*.  
 Sugars, 33-40.  
 Sulphanilic acid, 59.  
 Sulphur, Detection of, 3, 4.

## T.

Tannin, 60, 61, 65, 67.  
 Tartar emetic, 32.  
 Tartaric acid, 31, 32.  
 Tartrate, Calcium, 32.  
     Iron ammonium, 31.  
     Potassium, 31.  
     hydrogen, 31, 32.  
 Terpenes, 61.  
 Test, BEILSTEIN's, 2, 3, 10, 31.  
     Cacodyl, 16, 17.  
     Calcium-oxide, 3.  
     CARIUS', 3.  
     Caustic-alkali, 3.  
     Furfuraldehyde, 34, 35.  
     Iodoform, 13, 26.  
     KJELDAHL's, 2.  
     LASSAIGNE's, 2, 26.  
     Murexide, 46.  
     Mustard-oil, 12.  
     Nitroprusside, 4.  
     Nitrous-acid, 13.  
     Prussian-blue, 2, 40, 42.  
     Silver-mirror, 20, 30, 33, 54.  
     WILL and VARRENTRAP's, 2.  
 for acetic acid, 17, 22.  
     acetone, 21.  
     anthraquinone, 64.  
     antipyrine, 66.  
     brucine, 68.  
     ethyl alcohol, 26.  
     hexoses, Hydrochloric-acid, 35.  
     hydroxyl-groups, 27, 31.  
     lignin, 40.  
     naphthylamines, 64.  
     nitrous acid, *m*-Phenylenedi-  
         amine, 58.  
     phenol, Ferric-chloride, 49.



- Test for primary amines, 12.  
 pyridine, 65.  
 salicylic acid, 60.  
 starch, 38.  
 strychnine, 68.  
 tannin, 60, 61.  
 the double bond, VON BAEYER'S,  
 23, 24, 47, 65.  
 water in alcohol, 9, 10.
- Tests for albumin, 69.  
 aniline, 51.  
 carbon, 1, 2.  
 halogens, 2, 3.  
 hydrogen, 1, 2.  
 nitrogen, 2.  
 sulphur, 3, 4.
- Tetramethylalloxantine, 46.
- Thiocyanate, Ammonium, 3, 45.  
 Ferric, 45.  
 Potassium, 42.  
 Silver, 42, 43.
- Thiophen, 66.
- Toluene, 48.
- Transformation, Elaidic, 24.
- Tribromo-aniline, 51.  
 -phenol, 49.  
 -resorcinol, 57.
- Trimethylamine, 14.
- Triphenylmethane, 47.
- Trithiocarbonate, Barium, 43.
- Turpentine, Oil of, 61.
- U.
- Unsaturated acids, Monobasic, 24,  
 25.  
 hydrocarbons, 22-24.
- Urate, Ammonium, 46.  
 Di-potassium, 46.
- Urea, 6, 44, 45, 52.  
 nitrate, 44.  
 oxalate, 44.
- Uric acid, 46.
- Urine, 36, 44-46.  
 Estimation of urea in, 44, 45.
- V.
- VARRENTRAP'S method, WILL and,  
 2.
- W.
- Wax, Paraffin-, 8.
- WILL and VARRENTRAP'S method, 2.
- Wine, 9.
- WÖHLER'S synthesis of urea, 44.
- Wood, 27.  
 -charcoal, 4.
- X.
- Xanthate, Cupric, 43.  
 Cuprous, 43.  
 Potassium, 43.
- Xanthoprotein reaction, 69.





# SHORT-TITLE CATALOGUE

OF THE

PUBLICATIONS

OF

JOHN WILEY & SONS,

NEW YORK.

LONDON: CHAPMAN & HALL, LIMITED.

ARRANGED UNDER SUBJECTS.

Descriptive circulars sent on application. Books marked with an asterisk are sold at *net* prices only, a double asterisk (\*\*) books sold under the rules of the American Publishers' Association at *net* prices subject to an extra charge for postage. All books are bound in cloth unless otherwise stated.

## AGRICULTURE.

Armsby's Manual of Cattle-feeding.....	12mo, \$1	75
Principles of Animal Nutrition.....	8vo, 4	00
Budd and Hansen's American Horticultural Manual:		
Part I.—Propagation, Culture, and Improvement.....	12mo, 1	50
Part II.—Systematic Pomology.....	12mo, 1	50
Downing's Fruits and Fruit-trees of America.....	8vo, 5	00
Elliott's Engineering for Land Drainage.....	12mo, 1	50
Practical Farm Drainage.....	12mo, 1	00
Green's Principles of American Forestry.....	12mo, 1	50
Grotenfelt's Principles of Modern Dairy Practice. (Woll.).....	12mo, 2	00
Kemp's Landscape Gardening.....	12mo, 2	50
Maynard's Landscape Gardening as Applied to Home Decoration.....	12mo, 1	50
Sanderson's Insects Injurious to Staple Crops.....	12mo, 1	50
Insects Injurious to Garden Crops. ( <i>In preparation.</i> )		
Insects Injuring Fruits. ( <i>In preparation.</i> )		
Stockbridge's Rocks and Soils.....	8vo, 2	50
Woll's Handbook for Farmers and Dairymen.....	16mo, 1	50

## ARCHITECTURE.

Baldwin's Steam Heating for Buildings.....	12mo, 2	50
Berg's Buildings and Structures of American Railroads.....	4to, 5	00
Birkmire's Planning and Construction of American Theatres.....	8vo, 3	00
Architectural Iron and Steel.....	8vo, 3	50
Compound Riveted Girders as Applied in Buildings.....	8vo, 2	00
Planning and Construction of High Office Buildings.....	8vo, 3	50
Skeleton Construction in Buildings.....	8vo, 3	00
Briggs's Modern American School Buildings.....	8vo, 4	00
Carpenter's Heating and Ventilating of Buildings.....	8vo, 4	00
Freitag's Architectural Engineering. 2d Edition, Rewritten.....	8vo, 3	50
Fireproofing of Steel Buildings.....	8vo, 2	50
French and Ives's Stereotomy.....	8vo, 2	50
Gerhard's Guide to Sanitary House-inspection.....	16mo, 1	00
Theatre Fires and Panics.....	12mo, 1	50
Holly's Carpenters' and Joiners' Handbook.....	18mo, 0	75

	16mo, morocco,	5 00
Merrill's Stones for Building and Decoration.....	8vo,	5 00
Monckton's Stair-building .....	4to,	4 00
Patton's Practical Treatise on Foundations.....	8vo,	5 00
Peabody's Naval Architecture.....	8vo,	7 50
Siebert and Biggin's Modern Stone-cutting and Masonry.....	8vo,	1 50
Snow's Principal Species of Wood.....	8vo,	3 50
Sondericker's Graphic Statics with Applications to Trusses, Beams, and Arches.....	8vo,	2 00
Wait's Engineering and Architectural Jurisprudence.....	8vo,	6 00
	Sheep,	6 50
Law of Operations Preliminary to Construction in Engineering and Architecture.....	8vo,	5 00
	Sheep,	5 50
Law of Contracts.....	8vo,	3 00
Wood's Rustless Coatings: Corrosion and Electrolysis of Iron and Steel...	8vo,	4 00
Woodbury's Fire Protection of Mills.....	8vo,	2 50
Worcester and Atkinson's Small Hospitals, Establishment and Maintenance, Suggestions for Hospital Architecture, with Plans for a Small Hospital.....	12mo,	1 25
The World's Columbian Exposition of 1893.....	Large 4to,	1 00

## ARMY AND NAVY.

Bernadou's Smokeless Powder, Nitro-cellulose, and the Theory of the Cellulose Molecule.....	12mo,	2 50
* Bruff's Text-book Ordnance and Gunnery.....	8vo,	6 00
Chase's Screw Propellers and Marine Propulsion.....	8vo,	3 00
Craig's Azimuth.....	4to,	3 50
Crehore and Squire's Polarizing Photo-chronograph.....	8vo,	3 00
Cronkhite's Gunnery for Non-commissioned Officers.....	24mo, morocco,	2 00
* Davis's Elements of Law.....	8vo,	2 50
* Treatise on the Military Law of United States.....	8vo,	7 00
	Sheep,	7 50
De Brack's Cavalry Outpost Duties. (Carr.).....	24mo morocco,	2 00
Dietz's Soldier's First Aid Handbook.....	16mo, morocco,	1 25
* Dredge's Modern French Artillery .....	4to, half morocco,	15 00
Durand's Resistance and Propulsion of Ships.....	8vo,	5 00
* Dyer's Handbook of Light Artillery.....	12mo,	3 00
Eissler's Modern High Explosives.....	8vo,	4 00
* Fiebeger's Text-book on Field Fortification .....	Small 8vo,	2 00
Hamilton's The Gunner's Catechism.....	18mo,	1 00
* Hoff's Elementary Naval Tactics.....	8vo,	1 50
Ingalls's Handbook of Problems in Direct Fire.....	8vo,	4 00
* Ballistic Tables.....	8vo,	1 50
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I. and II. 8vo. each,		6 00
* Mahan's Permanent Fortifications. (Mercur.).....	8vo, half morocco,	7 50
Manual for Courts-martial .....	16mo, morocco,	1 50
* Mercur's Attack of Fortified Places.....	12mo,	2 00
* Elements of the Art of War.....	8vo,	4 00
Metcalfe's Cost of Manufactures—And the Administration of Workshops, Public and Private.....	8vo,	5 00
* Ordnance and Gunnery. 2 vols.....	12mo,	5 00
Murray's Infantry Drill Regulations.....	18mo, paper,	10
Peabody's Naval Architecture.....	8vo,	7 50
* Phelps's Practical Marine Surveying.....	8vo,	2 50
Powell's Army Officer's Examiner.....	12mo,	4 00
Sharpe's Art of Subsisting Armies in War.....	18mo, morocco,	1 50

* Walke's Lectures on Explosives.....	8vo	4 00
* Wheeler's Siege Operations and Military Mining.....	8vo,	2 00
Winthrop's Abridgment of Military Law.....	12mo,	2 50
Woodhull's Notes on Military Hygiene.....	16mo,	1 50
Young's Simple Elements of Navigation.....	16mo morocco,	1 00
Second Edition, Enlarged and Revised.....	16mo, morocco,	2 00

### ASSAYING.

Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe.....	12mo, morocco,	1 50
Furman's Manual of Practical Assaying.....	8vo,	3 00
Miller's Manual of Assaying.....	12mo,	1 00
O'Driscoll's Notes on the Treatment of Gold Ores.....	8vo,	2 00
Ricketts and Miller's Notes on Assaying.....	8vo,	3 00
Ulke's Modern Electrolytic Copper Refining.....	8vo,	3 00
Wilson's Cyanide Processes.....	12mo,	1 50
Chlorination Process.....	12mo,	1 50

### ASTRONOMY.

Comstock's Field Astronomy for Engineers.....	8vo,	2 50
Craig's Azimuth.....	4to,	3 50
Doolittle's Treatise on Practical Astronomy.....	8vo,	4 00
Gore's Elements of Geodesy.....	8vo,	2 50
Hayford's Text-book of Geodetic Astronomy.....	8vo,	3 00
Merriman's Elements of Precise Surveying and Geodesy.....	8vo,	2 50
* Michie and Harlow's Practical Astronomy.....	8vo,	3 00
* White's Elements of Theoretical and Descriptive Astronomy.....	12mo,	2 00

### BOTANY.

Davenport's Statistical Methods, with Special Reference to Biological Variation.....	16mo, morocco,	1 25
Thomé and Bennett's Structural and Physiological Botany.....	16mo,	2 25
Westermaier's Compendium of General Botany. (Schneider.).....	8vo,	2 00

### CHEMISTRY.

Adriance's Laboratory Calculations and Specific Gravity Tables.....	12mo,	1 25
Allen's Tables for Iron Analysis.....	8vo,	3 00
Arnold's Compendium of Chemistry. (Mandel.).....	Small 8vo,	3 50
Austen's Notes for Chemical Students.....	12mo,	1 50
* Austen and Langworthy. The Occurrence of Aluminium in Vegetable Products, Animal Products, and Natural Waters.....	8vo,	2 00
Bernadou's Smokeless Powder.—Nitro-cellulose, and Theory of the Cellulose Molecule.....	12mo,	2 50
Bolton's Quantitative Analysis.....	8vo,	1 50
* Browning's Introduction to the Rarer Elements.....	8vo,	1 50
Brush and Penfield's Manual of Determinative Mineralogy.....	8vo,	4 00
Classen's Quantitative Chemical Analysis by Electrolysis. (Boltwood.).....	8vo,	3 00
Cohn's Indicators and Test-papers.....	12mo,	2 00
Tests and Reagents.....	8vo,	3 00
Copeland's Manual of Bacteriology. ( <i>In preparation.</i> ).....		
Craft's Short Course in Qualitative Chemical Analysis. (Schaeffer.).....	12mo,	1 50
Dolezalek's Theory of the Lead Accumulator (Storage Battery). (Von Ende).....	12mo,	2 50
Drechsel's Chemical Reactions. (Merrill.).....	12mo,	1 25
Duhem's Thermodynamics and Chemistry. (Burgess.).....	8vo,	4 00
Eissler's Modern High Explosives.....	8vo,	4 00
Effront's Enzymes and their Applications. (Prescott.).....	8vo,	3 00
Erdmann's Introduction to Chemical Preparations. (Dunlap.).....	12mo,	1 25

Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe	12mo, morocco,	1 50
Fowler's Sewage Works Analyses.....	12mo,	2 00
Fresenius's Manual of Qualitative Chemical Analysis. (Wells.).....	8vo,	5 00
Manual of Qualitative Chemical Analysis. Part I. Descriptive. (Wells.)	8vo,	3 00
System of Instruction in Quantitative Chemical Analysis. (Cohn.)	2 vols.....	8vo, 12 50
Fuertes's Water and Public Health.....	12mo,	1 50
Furman's Manual of Practical Assaying.....	8vo,	3 00
*Getman's Exercises in Physical Chemistry.....	12mo,	2 00
Gill's Gas and Fuel Analysis for Engineers.....	12mo,	1 25
Grotenfelt's Principles of Modern Dairy Practice. (Woll.).....	12mo,	2 00
Hammarsten's Text-book of Physiological Chemistry. (Mandel.).....	8vo,	4 00
Helm's Principles of Mathematical Chemistry. (Morgan.).....	12mo,	1 50
Hering's Ready Reference Tables (Conversion Factors).....	16mo, morocco,	2 50
Hinds's Inorganic Chemistry.....	8vo,	3 00
* Laboratory Manual for Students.....	12mo,	75
Holleman's Text-book of Inorganic Chemistry. (Cooper.).....	8vo,	2 50
Text-book of Organic Chemistry. (Walker and Mott.).....	8vo,	2 50
* Laboratory Manual of Organic Chemistry. (Walker.).....	12mo,	1 00
Hopkins's Oil-chemists' Handbook.....	8vo,	3 00
Jackson's Directions for Laboratory Work in Physiological Chemistry.....	8vo,	1 25
Keep's Cast Iron.....	8vo,	2 50
Ladd's Manual of Quantitative Chemical Analysis.....	12mo,	1 00
Landauer's Spectrum Analysis. (Tingle.).....	8vo,	3 00
Lassar-Cohn's Practical Urinary Analysis. (Lorenz.).....	12mo,	1 00
Leach's The Inspection and Analysis of Food with Special Reference to State Control. ( <i>In preparation.</i> )		
Löb's Electrolysis and Electrosynthesis of Organic Compounds. (Lorenz.)	12mo,	1 00
Mandel's Handbook for Bio-chemical Laboratory.....	12mo,	1 50
* Martin's Laboratory Guide to Qualitative Analysis with the Blowpipe.....	12mo,	60
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.)	3d Edition, Rewritten.....	8vo, 4 00
Examination of Water. (Chemical and Bacteriological.).....	12mo,	1 25
Meyer's Determination of Radicles in Carbon Compounds. (Tingle.).....	12mo,	1 00
Miller's Manual of Assaying.....	12mo,	1 00
Mixter's Elementary Text-book of Chemistry.....	12mo,	1 50
Morgan's Outline of Theory of Solution and its Results.....	12mo,	1 00
Elements of Physical Chemistry.....	12mo,	2 00
Morse's Calculations used in Cane-sugar Factories.....	16mo, morocco,	1 50
Mulliken's General Method for the Identification of Pure Organic Compounds.	Vol. I.....	Large 8vo, 5 00
Nichols's Water-supply. (Considered mainly from a Chemical and Sanitary Standpoint, 1883.).....	8vo,	2 50
O'Brine's Laboratory Guide in Chemical Analysis.....	8vo,	2 00
O'Driscoll's Notes on the Treatment of Gold Ores.....	8vo,	2 00
Ost and Kolbeck's Text-book of Chemical Technology. (Lorenz—Borzat.)		
( <i>In preparation.</i> )		
Ostwald's School of Chemistry. Part One. (Ramsey.) ( <i>In press.</i> )		
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests,	8vo, paper,	50
Pictet's The Alkaloids and their Chemical Constitution. (Biddle.).....	8vo,	5 00
Pinner's Introduction to Organic Chemistry. (Austen.).....	12mo,	1 50
Poole's Calorific Power of Fuels.....	8vo,	3 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Reference to Sanitary Water Analysis.....	12mo,	1 25
* Reisig's Guide to Piece-dyeing.....	8vo,	25 00

Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint.	8vo,	2 00
Richards's Cost of Living as Modified by Sanitary Science.	12mo,	1 00
Cost of Food a Study in Dieteries.	12mo,	1 00
* Richards and Williams's The Dietary Computer	8vo,	1 50
Ricketts and Russell's Skeleton Notes upon Inorganic Chemistry. (Part I.—Non-metallic Elements.)	8vo, morocco,	75
Ricketts and Miller's Notes on Assaying	8vo,	3 00
Rideal's Sewage and the Bacterial Purification of Sewage	8vo,	3 50
Disinfection and the Preservation of Food	8vo,	4 00
Ruddiman's Incompatibilities in Prescriptions	8vo,	2 00
Sabin's Industrial and Artistic Technology of Paints and Varnish. ( <i>In press.</i> )		
Salkowski's Physiological and Pathological Chemistry. (Orndorff.)	8vo,	2 50
Schimpf's Text-book of Volumetric Analysis	12mo,	2 50
Essentials of Volumetric Analysis	12mo,	1 25
Spencer's Handbook for Chemists of Beet-sugar Houses	16mo, morocco,	3 00
Handbook for Sugar Manufacturers and their Chemists	16mo, morocco,	2 00
Stockbridge's Rocks and Soils	8vo,	2 50
* Tillman's Elementary Lessons in Heat	8vo,	1 50
* Descriptive General Chemistry	8vo,	3 00
Treadwell's Qualitative Analysis. (Hall.)	8vo,	3 00
Quantitative Analysis. (Hall.)	8vo,	4 00
Turneure and Russell's Public Water-supplies	8vo,	5 00
Van Deventer's Physical Chemistry for Beginners. (Boltwood.)	12mo,	1 50
* Walke's Lectures on Explosives	8vo,	4 00
Wassermann's Immune Sera: Hæmolysins, Cytotoxins, and Precipitins. (Boltwood.)	12mo,	1 00
Wells's Laboratory Guide in Qualitative Chemical Analysis	8vo,	1 50
Short Course in Inorganic Qualitative Chemical Analysis for Engineering Students	12mo,	1 50
Whipple's Microscopy of Drinking-water	8vo,	3 50
Wiechmann's Sugar Analysis	Small 8vo,	2 50
Wilson's Cyanide Processes	12mo,	1 50
Chlorination Process	12mo,	1 50
Wulling's Elementary Course in Inorganic Pharmaceutical and Medical Chemistry	12mo,	2 00

## CIVIL ENGINEERING.

### BRIDGES AND ROOFS. HYDRAULICS. MATERIALS OF ENGINEERING RAILWAY ENGINEERING.

Baker's Engineers' Surveying Instruments	12mo,	3 00
Bixby's Graphical Computing Table	Paper 19½ X 24½ inches.	25
** Burr's Ancient and Modern Engineering and the Isthmian Canal. (Postage, 27 cents additional.)	8vo, net,	3 50
Comstock's Field Astronomy for Engineers	8vo,	2 50
Davis's Elevation and Stadia Tables	8vo,	1 00
Elliot's Engineering for Land Drainage	12mo,	1 50
Practical Farm Drainage	12mo,	1 00
Folwell's Sewerage. (Designing and Maintenance.)	8vo,	3 00
Freitag's Architectural Engineering. 2d Edition, Rewritten	8vo,	3 50
French and Ives's Stereotomy	8vo,	2 50
Goodhue's Municipal Improvements	12mo,	1 75
Goodrich's Economic Disposal of Towns' Refuse	8vo,	3 50
Gore's Elements of Geodesy	8vo,	2 50
Hayford's Text-book of Geodetic Astronomy	8vo,	3 00
Hering's Ready Reference Tables (Conversion Factors)	16mo, morocco,	2 50
Howe's Retaining Walls for Earth	12mo,	1 25
Johnson's Theory and Practice of Surveying	Small 8vo,	4 00
Statics by Algebraic and Graphic Methods	8vo,	2 00



Kiersted's Sewage Disposal.....	12mo,	1 25
Laplace's Philosophical Essay on Probabilities. (Truscott and Emory.)	12mo,	2 00
Mahan's Treatise on Civil Engineering. (1873.) (Wood.)	8vo,	5 00
* Descriptive Geometry.....	8vo,	1 50
Merriman's Elements of Precise Surveying and Geodesy.....	8vo,	2 50
Elements of Sanitary Engineering.....	8vo,	2 00
Merriman and Brooks's Handbook for Surveyors.....	16mo, morocco,	2 00
Nugent's Plane Surveying.....	8vo,	3 50
Ogden's Sewer Design.....	12mo,	2 00
Patton's Treatise on Civil Engineering.....	8vo half leather,	7 50
Reed's Topographical Drawing and Sketching.....	4to,	5 00
Rideal's Sewage and the Bacterial Purification of Sewage.....	8vo,	3 50
Siebert and Biggin's Modern Stone-cutting and Masonry.....	8vo,	1 50
Smith's Manual of Topographical Drawing. (McMillan.)	8vo,	2 50
Sondericker's Graphic Statics, with Applications to Trusses, Beams, and Arches.....	8vo,	2 00
* Trantwine's Civil Engineer's Pocket-book.....	16mo, morocco,	5 00
Wait's Engineering and Architectural Jurisprudence.....	8vo,	6 00
	Sheep,	6 50
Law of Operations Preliminary to Construction in Engineering and Archi- tecture.....	8vo,	5 00
	Sheep,	5 50
Law of Contracts.....	8vo,	3 00
Warren's Stereotomy—Problems in Stone-cutting.....	8vo,	2 50
Webb's Problems in the Use and Adjustment of Engineering Instruments. 16mo, morocco,		1 25
* Wheeler's Elementary Course of Civil Engineering.....	8vo,	4 00
Wilson's Topographic Surveying.....	8vo,	3 50

## BRIDGES AND ROOFS.

Boller's Practical Treatise on the Construction of Iron Highway Bridges..	8vo,	2 00
* Thames River Bridge.....	4to, paper,	5 00
Burr's Course on the Stresses in Bridges and Roof Trusses, Arched Ribs, and Suspension Bridges.....	8vo,	3 50
Du Bois's Mechanics of Engineering. Vol. II.....	Small 4to,	10 00
Foster's Treatise on Wooden Trestle Bridges.....	4to,	5 00
Fowler's Cofferdam Process for Piers.....	8vo,	2 50
Greene's Roof Trusses.....	8vo,	1 25
Bridge Trusses.....	8vo,	2 50
Arches in Wood, Iron, and Stone.....	8vo,	2 50
Howe's Treatise on Arches.....	8vo,	4 00
Design of Simple Roof-trusses in Wood and Steel.....	8vo,	2 00
Johnson, Bryan, and Turneure's Theory and Practice in the Designing of Modern Framed Structures.....	Small 4to,	10 00
Merriman and Jacoby's Text-book on Roofs and Bridges:		
Part I.—Stresses in Simple Trusses.....	8vo,	2 50
Part II.—Graphic Statics.....	8vo,	2 50
Part III.—Bridge Design. 4th Edition, Rewritten.....	8vo,	2 50
Part IV.—Higher Structures.....	8vo,	2 50
Morison's Memphis Bridge.....	4to,	10 00
Waddell's De Pontibus, a Pocket-book for Bridge Engineers..	16mo, morocco,	3 00
Specifications for Steel Bridges.....	12mo,	1 25
Wood's Treatise on the Theory of the Construction of Bridges and Roofs.	8vo,	2 00
Wright's Designing of Draw-spans:		
Part I.—Plate-girder Draws.....	8vo,	2 50
Part II.—Riveted-truss and Pin-connected Long-span Draws.....	8vo,	2 50
Two parts in one volume.....	8vo,	3 50

## HYDRAULICS.

Bazin's Experiments upon the Contraction of the Liquid Vein Issuing from an Orifice. (Trautwine.)	8vo,	2 00
Bovey's Treatise on Hydraulics.	8vo,	5 00
Church's Mechanics of Engineering.	8vo,	6 00
Diagrams of Mean Velocity of Water in Open Channels.	paper,	1 50
Coffin's Graphical Solution of Hydraulic Problems.	16mo, morocco,	2 50
Flather's Dynamometers, and the Measurement of Power.	12mo,	3 00
Folwell's Water-supply Engineering.	8vo,	4 00
Frizell's Water-power.	8vo,	5 00
Fuertes's Water and Public Health.	12mo,	1 50
Water-filtration Works.	12mo,	2 50
Ganguillet and Kutter's General Formula for the Uniform Flow of Water in Rivers and Other Channels. (Hering and Trautwine.)	8vo,	4 00
Hazen's Filtration of Public Water-supply.	8vo,	3 00
Hazlehurst's Towers and Tanks for Water-works.	8vo,	2 50
Herschel's 115 Experiments on the Carrying Capacity of Large, Riveted, Metal Conduits.	8vo,	2 00
Mason's Water-supply. (Considered Principally from a Sanitary Stand-point.) 3d Edition, Rewritten.	8vo,	4 00
Merriman's Treatise on Hydraulics. 9th Edition, Rewritten.	8vo,	5 00
* Michie's Elements of Analytical Mechanics.	8vo,	4 00
Schuyler's Reservoirs for Irrigation, Water-power, and Domestic Water-supply.	Large 8vo,	5 00
** Thomas and Watt's Improvement of Rivers. (Post., 44 c. additional),	4to,	6 00
Turneure and Russell's Public Water-supplies.	8vo,	5 00
Wegmann's Design and Construction of Dams.	4to,	5 00
Water-supply of the City of New York from 1658 to 1895.	4to,	10 00
Weisbach's Hydraulics and Hydraulic Motors. (Du Bois.)	8vo,	5 00
Wilson's Manual of Irrigation Engineering.	Small 8vo,	4 00
Wolff's Windmill as a Prime Mover.	8vo,	3 00
Wood's Turbines.	8vo,	2 50
Elements of Analytical Mechanics.	8vo,	3 00

## MATERIALS OF ENGINEERING.

Baker's Treatise on Masonry Construction.	8vo,	5 00
Roads and Pavements.	8vo,	5 00
Black's United States Public Works.	Oblong 4to,	5 00
Bovey's Strength of Materials and Theory of Structures.	8vo,	7 50
Burr's Elasticity and Resistance of the Materials of Engineering. 6th Edition, Rewritten.	8vo,	7 50
Byrne's Highway Construction.	8vo,	5 00
Inspection of the Materials and Workmanship Employed in Construction.	16mo,	3 00
Church's Mechanics of Engineering.	8vo,	6 00
Du Bois's Mechanics of Engineering. Vol. I.	Small 4to,	7 50
Johnson's Materials of Construction.	Large 8vo,	6 00
Keep's Cast Iron.	8vo,	2 50
Lanza's Applied Mechanics.	8vo,	7 50
Martens's Handbook on Testing Materials. (Henning.) 2 vols.	8vo,	7 50
Merrill's Stones for Building and Decoration.	8vo,	5 00
Merriman's Text-book on the Mechanics of Materials.	8vo,	4 00
Strength of Materials.	12mo,	1 00
Metcalf's Steel. A Manual for Steel-users.	12mo,	2 00
Patton's Practical Treatise on Foundations.	8vo,	5 00

Rockwell's Roads and Pavements in France.....	12mo,	1 25
Smith's Materials of Machines.....	12mo,	1 00
Snow's Principal Species of Wood.....	8vo,	3 50
Spalding's Hydraulic Cement.....	12mo,	2 00
Text-book on Roads and Pavements.....	12mo,	2 00
Thurston's Materials of Engineering. 3 Parts.....	8vo,	8 00
Part I.—Non-metallic Materials of Engineering and Metallurgy....	8vo,	2 00
Part II.—Iron and Steel.....	8vo,	3 50
Part III.—A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	8vo,	2 50
Thurston's Text-book of the Materials of Construction.....	8vo,	5 00
Tillson's Street Pavements and Paving Materials.....	8vo,	4 00
Waddell's De Pontibus. (A Pocket-book for Bridge Engineers.)..	16mo, mor.,	3 00
Specifications for Steel Bridges.....	12mo,	1 25
Wood's Treatise on the Resistance of Materials, and an Appendix on the Pres- ervation of Timber.....	8vo,	2 00
Elements of Analytical Mechanics.....	8vo,	3 00
Wood's Rustless Coatings; Corrosion and Electrolysis of Iron and Steel..	8vo,	4 00

## RAILWAY ENGINEERING.

Andrews's Handbook for Street Railway Engineers. 3×5 inches.	morocco,	1 25
Berg's Buildings and Structures of American Railroads.....	4to,	5 00
Brooks's Handbook of Street Railroad Location.....	16mo, morocco,	1 50
Butts's Civil Engineer's Field-book.....	16mo, morocco,	2 50
Crandall's Transition Curve.....	16mo, morocco,	1 50
Railway and Other Earthwork Tables.....8vo,		
Dawson's "Engineering" and Electric Traction Pocket-book.	16mo, morocco,	1 50
Dredge's History of the Pennsylvania Railroad: (1879).....	Paper,	5 00
* Drinker's Tunneling, Explosive Compounds, and Rock Drills,	4to, half mor.,	25 00
Fisher's Table of Cubic Yards.....	Cardboard,	25
Godwin's Railroad Engineers' Field-book and Explorers' Guide.....	16mo, mor.,	2 50
Howard's Transition Curve Field-book.....	16mo, morocco,	1 50
Hudson's Tables for Calculating the Cubic Contents of Excavations and Em- bankments.....	8vo,	1 00
Molitor and Beard's Manual for Resident Engineers.....	16mo,	1 00
Nagle's Field Manual for Railroad Engineers.....	16mo, morocco,	3 00
Philbrick's Field Manual for Engineers.....	16mo, morocco,	3 00
Searles's Field Engineering.....	16mo, morocco,	3 00
Railroad Spiral.....	16mo, morocco,	1 50
Taylor's Prismoidal Formulæ and Earthwork.....	8vo,	1 50
* Trautwine's Method of Calculating the Cubic Contents of Excavations and Embankments by the Aid of Diagrams.....	8vo,	2 00
The Field Practice of Laying Out Circular Curves for Railroads.....	12mo, morocco,	2 50
Cross-section Sheet.....	Paper,	25
Webb's Railroad Construction. 2d Edition, Rewritten.....	16mo, morocco,	5 00
Wellington's Economic Theory of the Location of Railways.....	Small 8vo,	5 00

DRAWING.

Barr's Kinematics of Machinery.....	8vo,	2 50
* Bartlett's Mechanical Drawing.....	8vo,	3 00
* " " Abridged Ed.....	8vo,	1 50
Coolidge's Manual of Drawing.....	8vo, paper,	1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical Engineers. ( <i>In press.</i> )		
Durley's Kinematics of Machines.....	8vo,	4 00

Hill's Text-book on Shades and Shadows, and Perspective.....	8vo,	2 00
Jamison's Elements of Mechanical Drawing. ( <i>In press.</i> )		
Jones's Machine Design:		
Part I.—Kinematics of Machinery.....	8vo,	1 50
Part II.—Form, Strength, and Proportions of Parts.....	8vo,	3 00
MacCord's Elements of Descriptive Geometry.....	8vo,	3 00
Kinematics; or, Practical Mechanism.....	8vo,	5 00
Mechanical Drawing.....	4to,	4 00
Velocity Diagrams.....	8vo,	1 50
* Mahan's Descriptive Geometry and Stone-cutting.....	8vo,	1 50
Industrial Drawing. (Thompson.).....	8vo,	3 50
Reed's Topographical Drawing and Sketching.....	4to,	5 00
Reid's Course in Mechanical Drawing.....	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.....	8vo,	3 00
Robinson's Principles of Mechanism.....	8vo,	3 00
Smith's Manual of Topographical Drawing. (McMillan.).....	8vo,	2 50
Warren's Elements of Plane and Solid Free-hand Geometrical Drawing.....	12mo,	1 00
Drafting Instruments and Operations.....	12mo,	1 25
Manual of Elementary Projection Drawing.....	12mo,	1 50
Manual of Elementary Problems in the Linear Perspective of Form and Shadow.....	12mo,	1 00
Plane Problems in Elementary Geometry.....	12mo,	1 25
Primary Geometry.....	12mo,	75
Elements of Descriptive Geometry, Shadows, and Perspective.....	8vo,	3 50
General Problems of Shades and Shadows.....	8vo,	3 00
Elements of Machine Construction and Drawing.....	8vo,	7 50
Problems, Theorems, and Examples in Descriptive Geometry.....	8vo,	2 50
Weisbach's Kinematics and the Power of Transmission. (Hermann and Klein.).....	8vo,	5 00
Whelpley's Practical Instruction in the Art of Letter Engraving.....	12mo,	2 00
Wilson's Topographic Surveying.....	8vo,	3 50
Free-hand Perspective.....	8vo,	2 50
Free-hand Lettering.....	8vo,	1 00
Woolf's Elementary Course in Descriptive Geometry.....	Large 8vo,	3 00

## ELECTRICITY AND PHYSICS.

Anthony and Brackett's Text-book of Physics. (Magie.).....	Small 8vo,	3 00
Anthony's Lecture-notes on the Theory of Electrical Measurements.....	12mo,	1 00
Benjamin's History of Electricity.....	8vo,	3 00
Voltaic Cell.....	8vo,	3 00
Classen's Quantitative Chemical Analysis by Electrolysis. (Boltwood.).....	8vo,	3 00
Crehore and Squier's Polarizing Photo-chronograph.....	8vo,	3 00
Dawson's "Engineering" and Electric Traction Pocket-book.....	16mo, morocco,	5 00
Dolezalek's Theory of the Lead Accumulator (Storage Battery). (Von Ende.).....	12mo,	2 50
Duhem's Thermodynamics and Chemistry. (Burgess.).....	8vo,	4 00
Father's Dynamometers, and the Measurement of Power.....	12mo,	3 00
Gilbert's De Magnete. (Mottelay.).....	8vo,	2 50
Hanchett's Alternating Currents Explained.....	12mo,	1 00
Hering's Ready Reference Tables (Conversion Factors).....	16mo, morocco,	2 50
Holman's Precision of Measurements.....	8vo,	2 00
Telescopic Mirror-scale Method, Adjustments, and Tests.....	Large 8vo,	75
Landauer's Spectrum Analysis. (Tingle.).....	8vo,	3 00
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.).....	12mo,	3 00
Löb's Electrolysis and Electrosynthesis of Organic Compounds. (Lorenz.).....	12mo,	1 00
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I and II. 8vo, each,		6 00
* Michie. Elements of Wave Motion Relating to Sound and Light.....	8vo,	4 00

Niaudet's Elementary Treatise on Electric Batteries. (Fishback.).....	12mo,	2 50
* Rosenberg's Electrical Engineering. (Haldane Gee—Kinzbrunner.)....	8vo,	1 50
Ryan, Norris, and Hoxie's Electrical Machinery. Vol. I.....	8vo,	2 50
Thurston's Stationary Steam-engines.....	8vo,	2 50
* Tillman's Elementary Lessons in Heat.....	8vo,	1 50
Tory and Pitcher's Manual of Laboratory Physics.....	Small 8vo,	2 00
Ulke's Modern Electrolytic Copper Refining .....	8vo,	3 00

## LAW.

* Davis's Elements of Law .....	8vo,	2 50
* Treatise on the Military Law of United States.....	8vo,	7 00
* .....	Sheep,	7 50
Manual for Courts-martial.....	16mo, morocco,	1 50
Wait's Engineering and Architectural Jurisprudence.....	8vo,	6 00
.....	Sheep,	6 50
• Law of Operations Preliminary to Construction in Engineering and Archi- tecture.....	8vo,	5 00
.....	Sheep,	5 50
Law of Contracts.....	8vo,	3 00
Winthrop's Abridgment of Military Law.....	12mo,	2 50

## MANUFACTURES.

Bernadou's Smokeless Powder—Nitro-cellulose and Theory of the Cellulose Molecule.....	12mo,	2 50
Bolland's Iron Founder.....	12mo,	2 50
“The Iron Founder,” Supplement.....	12mo,	2 50
Encyclopedia of Founding and Dictionary of Foundry Terms Used in the Practice of Moulding.....	12mo,	3 00
Eissler's Modern High Explosives.....	8vo,	4 00
Effront's Enzymes and their Applications. (Prescott.).....	8vo,	3 00
Fitzgerald's Boston Machinist.....	18mo,	1 00
Ford's Boiler Making for Boiler Makers.....	18mo,	1 00
Hopkins's Oil-chemists' Handbook.....	8vo,	3 00
Keep's Cast Iron.....	8vo,	2 50
Leach's The Inspection and Analysis of Food with Special Reference to State Control. ( <i>In preparation.</i> ).....		
Metcalf's Steel. A Manual for Steel-users.....	12mo,	2 00
Metcalf's Cost of Manufactures—And the Administration of Workshops, Public and Private.....	8vo,	5 00
Meyer's Modern Locomotive Construction.....	4to,	10 00
Morse's Calculations used in Cane-sugar Factories.....	16mo, morocco,	1 50
* Reisig's Guide to Piece-dyeing.....	8vo,	25 00
Smith's Press-working of Metals.....	8vo,	3 00
Spalding's Hydraulic Cement.....	12mo,	2 00
Spencer's Handbook for Chemists of Beet-sugar Houses.....	16mo, morocco,	3 00
Handbook for Sugar Manufacturers and their Chemists.....	16mo, morocco,	2 00
Thurston's Manual of Steam-boilers, their Designs, Construction and Opera- tion.....	8vo,	5 00
* Walke's Lectures on Explosives.....	8vo,	4 00
West's American Foundry Practice.....	12mo,	2 50
Moulder's Text-book.....	12mo,	2 50
Wiechmann's Sugar Analysis.....	Small 8vo,	2 50
Wolff's Windmill as a Prime Mover.....	8vo,	3 00
Woodbury's Fire Protection of Mills.....	8vo,	2 50
Wood's Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	8vo,	4 00

## MATHEMATICS.

Baker's Elliptic Functions.....	8vo,	1 50
* Bass's Elements of Differential Calculus.....	12mo,	4 00
Briggs's Elements of Plane Analytic Geometry.....	12mo,	1 00
Compton's Manual of Logarithmic Computations.....	12mo,	1 50
Davis's Introduction to the Logic of Algebra.....	8vo,	1 50
* Dickson's College Algebra.....	Large 12mo,	1 50
*   Answers to Dickson's College Algebra.....	8vo, paper,	25
*   Introduction to the Theory of Algebraic Equations.....	Large 12mo,	1 25
Halsted's Elements of Geometry.....	8vo,	1 75
Elementary Synthetic Geometry.....	8vo,	1 50
Rational Geometry.....	12mo,	1 75
* Johnson's Three-place Logarithmic Tables: Vest-pocket size.....	paper,	15
100 copies for.....		5 00
Mounted on heavy cardboard, 8 X 10 inches,.....		25
10 copies for.....		2 00
Elementary Treatise on the Integral Calculus.....	Small 8vo,	1 50
Curve Tracing in Cartesian Co-ordinates.....	12mo,	1 00
Treatise on Ordinary and Partial Differential Equations.....	Small 8vo,	3 50
Theory of Errors and the Method of Least Squares.....	12mo,	1 50
*   Theoretical Mechanics.....	12mo,	3 00
Laplace's Philosophical Essay on Probabilities. (Truscott and Emory.)	12mo,	2 00
* Ludlow and Bass. Elements of Trigonometry and Logarithmic and Other Tables.....	8vo,	3 00
Trigonometry and Tables published separately.....	Each,	2 00
* Ludlow's Logarithmic and Trigonometric Tables.....	8vo,	1 00
Maurer's Technical Mechanics.....	8vo,	4 00
Merriman and Woodward's Higher Mathematics.....	8vo,	5 00
Merriman's Method of Least Squares.....	8vo,	2 00
Rice and Johnson's Elementary Treatise on the Differential Calculus. Sm.,	8vo,	3 00
Differential and Integral Calculus. 2 vols. in one.....	Small 8vo,	2 50
Sabin's Industrial and Artistic Technology of Paints and Varnish. ( <i>In press.</i> )		
Wood's Elements of Co-ordinate Geometry.....	8vo,	2 00
Trigonometry: Analytical, Plane, and Spherical.....	12mo,	1 00

## MECHANICAL ENGINEERING.

### MATERIALS OF ENGINEERING, STEAM-ENGINES AND BOILERS.

Baldwin's Steam Heating for Buildings.....	12mo,	2 50
Barr's Kinematics of Machinery.....	8vo,	2 50
* Bartlett's Mechanical Drawing.....	8vo,	3 00
*   "   "   "   Abridged Ed.....	8vo,	1 50
Benjamin's Wrinkles and Recipes.....	12mo,	2 00
Carpenter's Experimental Engineering.....	8vo,	6 00
Heating and Ventilating Buildings.....	8vo,	4 00
Cary's Smoke Suppression in Plants using Bituminous Coal. ( <i>In preparation.</i> )		
Clerk's Gas and Oil Engine.....	Small 8vo,	4 00
Coolidge's Manual of Drawing.....	8vo, paper,	1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical Engineers. ( <i>In press.</i> )		
Cromwell's Treatise on Toothed Gearing.....	12mo,	1 50
Treatise on Belts and Pulleys.....	12mo,	1 50
Durley's Kinematics of Machines.....	8vo,	4 00
Flather's Dynamometers and the Measurement of Power.....	12mo,	3 00
Rope Driving.....	12mo,	2 00

Gill's Gas and Fuel Analysis for Engineers .....	12mo, 1 2
Hall's Car Lubrication.....	12mo, 1 0
Hering's Ready Reference Tables (Conversion Factors).....	16mo, morocco, 2 5
Hutton's The Gas Engine .....	8vo, 5 0
Jones's Machine Design:	
Part I.—Kinematics of Machinery.....	8vo, 1 5
Part II.—Form, Strength, and Proportions of Parts.....	8vo, 3 0
Kent's Mechanical Engineer's Pocket-book.....	16mo, morocco, 5 0
Kerr's Power and Power Transmission.....	8vo, 2 0
MacCord's Kinematics; or, Practical Mechanism.....	8vo, 5 0
Mechanical Drawing.....	4to, 4 0
Velocity Diagrams.....	8vo, 1 5
Mahan's Industrial Drawing. (Thompson.).....	8vo, 3 5
Poole's Calorific Power of Fuels.....	8vo, 3 0
Reid's Course in Mechanical Drawing.....	8vo, 2 0
Text-book of Mechanical Drawing and Elementary Machine Design.....	8vo, 3 0
Richards's Compressed Air.....	12mo, 1 5
Robinson's Principles of Mechanism.....	8vo, 3 0
Smith's Press-working of Metals.....	8vo, 3 0
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work.....	8vo, 3 0
Animal as a Machine and Prime Motor, and the Laws of Energetics.....	12mo, 1 0
Warren's Elements of Machine Construction and Drawing.....	8vo, 7 5
Weisbach's Kinematics and the Power of Transmission. Herrmann—Klein.).....	8vo, 5 0
Machinery of Transmission and Governors. (Herrmann—Klein.).....	8vo, 5 0
Hydraulics and Hydraulic Motors. (Du Bois.).....	8vo, 5 0
Wolff's Windmill as a Prime Mover.....	8vo, 3 0
Wood's Turbines.....	8vo, 2 5

## MATERIALS OF ENGINEERING.

Bovey's Strength of Materials and Theory of Structures.....	8vo, 7 5
Burr's Elasticity and Resistance of the Materials of Engineering. 6th Edition, Reset.....	8vo, 7 5
Church's Mechanics of Engineering.....	8vo, 6 0
Johnson's Materials of Construction.....	Large 8vo, 6 0
Keep's Cast Iron.....	8vo, 2 5
Lanza's Applied Mechanics.....	8vo, 7 5
Martens's Handbook on Testing Materials. (Henning.).....	8vo, 7 5
Merriman's Text-book on the Mechanics of Materials.....	8vo, 4 0
Strength of Materials.....	12mo, 1 0
Metcalf's Steel. A Manual for Steel-users.....	12mo, 2 0
Smith's Materials of Machines.....	12mo, 1 0
Thurston's Materials of Engineering.....	3 vols, 8vo, 8 0
Part II.—Iron and Steel.....	8vo, 3 5
Part III.—A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	8vo, 2 5
Text-book of the Materials of Construction.....	8vo, 5 0
Wood's Treatise on the Resistance of Materials and an Appendix on the Preservation of Timber.....	8vo, 2 0
Elements of Analytical Mechanics.....	8vo, 3 0
Wood's Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	8vo, 4 0

## STEAM-ENGINES AND BOILERS.

Carnot's Reflections on the Motive Power of Heat. (Thurston.).....	12mo, 1 5
Dawson's "Engineering" and Electric Traction Pocket-book.....	16mo, mor., 5 0
Ford's Boiler Making for Boiler Makers.....	18mo, 1 0

Goss's Locomotive Sparks.....	8vo,	2 00
Hemenway's Indicator Practice and Steam-engine Economy.....	12mo,	2 00
Hutton's Mechanical Engineering of Power Plants.....	8vo,	5 00
Heat and Heat-engines.....	8vo,	5 00
Kent's Steam-boiler Economy.....	8vo,	4 00
Kneass's Practice and Theory of the Injector.....	8vo	1 50
MacCord's Slide-valves.....	8vo,	2 00
Meyer's Modern Locomotive Construction.....	4to,	10 00
Peabody's Manual of the Steam-engine Indicator.....	12mo,	1 50
Tables of the Properties of Saturated Steam and Other Vapors.....	8vo,	1 00
Thermodynamics of the Steam-engine and Other Heat-engines.....	8vo,	5 00
Valve-gears for Steam-engines.....	8vo,	2 50
Peabody and Miller's Steam-boilers.....	8vo,	4 00
Pray's Twenty Years with the Indicator.....	Large 8vo,	2 50
Pupin's Thermodynamics of Reversible Cycles in Gases and Saturated Vapors. (Osterberg.).....	12mo,	1 25
Reagan's Locomotives: Simple, Compound, and Electric.....	12mo,	2 50
Rontgen's Principles of Thermodynamics. (Du Bois.).....	8vo,	5 00
Sinclair's Locomotive Engine Running and Management.....	12mo,	2 00
Smart's Handbook of Engineering Laboratory Practice.....	12mo,	2 50
Snow's Steam-boiler Practice.....	8vo,	3 00
Spangler's Valve-gears.....	8vo,	2 50
Notes on Thermodynamics.....	12mo,	1 00
Spangler, Greene, and Marshall's Elements of Steam-engineering.....	8vo,	3 00
Thurston's Handy Tables.....	8vo,	1 50
Manual of the Steam-engine.....	2 vols. 8vo,	10 00
Part I.—History, Structure, and Theory.....	8vo,	6 00
Part II.—Design, Construction, and Operation.....	8vo,	6 00
Handbook of Engine and Boiler Trials, and the Use of the Indicator and the Prony Brake.....	8vo	5 00
Stationary Steam-engines.....	8vo,	2 50
Steam-boiler Explosions in Theory and in Practice.....	12mo	1 50
Manual of Steam-boilers, Their Designs, Construction, and Operation.....	8vo,	5 00
Weisbach's Heat, Steam, and Steam-engines. (Du Bois.).....	8vo,	5 00
Whitham's Steam-engine Design.....	8vo,	5 00
Wilson's Treatise on Steam-boilers. (Flather.).....	16mo,	2 50
Wood's Thermodynamics Heat Motors, and Refrigerating Machines....	8vo,	4 00

## MECHANICS AND MACHINERY.

Barr's Kinematics of Machinery.....	8vo,	2 50
Bovey's Strength of Materials and Theory of Structures.....	8vo,	7 50
Chase's The Art of Pattern-making.....	12mo,	2 50
Chordal.—Extracts from Letters.....	12mo,	2 00
Church's Mechanics of Engineering.....	8vo,	6 00
Notes and Examples in Mechanics.....	8vo,	2 00
Compton's First Lessons in Metal-working.....	12mo,	1 50
Compton and De Groodt's The Speed Lathe.....	12mo,	1 50
Cromwell's Treatise on Toothed Gearing.....	12mo,	1 50
Treatise on Belts and Pulleys.....	12mo,	1 50
Dana's Text-book of Elementary Mechanics for the Use of Colleges and Schools.....	12mo,	1 50
Dingey's Machinery Pattern Making.....	12mo,	2 00
Dredge's Record of the Transportation Exhibits Building of the World's Columbian Exposition of 1893.....	4to, half morocco,	5 00



# Du Bois's Elementary Principles of Mechanics:

Vol. I.—Kinematics.....	8vo,	3 50
Vol. II.—Statics.....	8vo,	4 00
Vol. III.—Kinetics.....	8vo,	3 50
Mechanics of Engineering. Vol. I.....	Small 4to,	7 50
Vol. II.....	Small 4to,	10 00
Durley's Kinematics of Machines.....	8vo,	4 00
Fitzgerald's Boston Machinist.....	16mo,	1 00
Flather's Dynamometers, and the Measurement of Power.....	12mo,	3 00
Rope Driving.....	12mo,	2 00
Goss's Locomotive Sparks.....	8vo	2 00
Hall's Car Lubrication.....	12mo,	1 00
Holly's Art of Saw Filing.....	18mo,	75
* Johnson's Theoretical Mechanics.....	12mo,	3 00
Statics by Graphic and Algebraic Methods.....	8vo,	2 00
Jones's Machine Design:		
Part I.—Kinematics of Machinery.....	8vo,	1 50
Part II.—Form, Strength, and Proportions of Parts.....	8vo,	3 00
Kerr's Power and Power Transmission.....	8vo,	2 00
Lanza's Applied Mechanics.....	8vo,	7 50
MacCord's Kinematics; or, Practical Mechanism.....	8vo,	5 00
Velocity Diagrams.....	8vo,	1 50
Maurer's Technical Mechanics.....	8vo,	4 00
Merriman's Text-book on the Mechanics of Materials.....	8vo,	4 00
* Michie's Elements of Analytical Mechanics.....	8vo,	4 00
Reagan's Locomotives: Simple, Compound, and Electric.....	12mo,	2 50
Reid's Course in Mechanical Drawing.....	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.....	8vo,	3 00
Richards's Compressed Air.....	12mo,	1 50
Robinson's Principles of Mechanism.....	8vo,	3 00
Ryan, Norris, and Hoxie's Electrical Machinery. Vol. I.....	8vo,	2 50
Sinclair's Locomotive-engine Running and Management.....	12mo,	2 00
Smith's Press-working of Metals.....	8vo,	3 00
Materials of Machines.....	12mo,	1 00
Spangler, Greene, and Marshall's Elements of Steam-engineering.....	8vo,	3 00
Thurston's Treatise on Friction and Lost Work in Machinery and Mill Work.....	8vo,	3 00
Animal as a Machine and Prime Motor, and the Laws of Energetics.....	12mo,	1 00
Warren's Elements of Machine Construction and Drawing.....	8vo,	7 50
Weisbach's Kinematics and the Power of Transmission. (Herrmann—Klein.).....	8vo,	5 00
Machinery of Transmission and Governors. (Herrmann—Klein.).....	8vo,	5 00
Wood's Elements of Analytical Mechanics.....	8vo,	3 00
Principles of Elementary Mechanics.....	12mo,	1 25
Turbines.....	8vo,	2 50
The World's Columbian Exposition of 1893.....	4to,	1 00

## METALLURGY.

### Egleston's Metallurgy of Silver, Gold, and Mercury:

Vol. I.—Silver.....	8vo,	7 50
Vol. II.—Gold and Mercury.....	8vo,	7 50
** Iles's Lead-smelting. (Postage 9 cents additional.).....	12mo,	2 50
Keep's Cast Iron.....	8vo,	2 50
Kunhardt's Practice of Ore Dressing in Europe.....	8vo,	1 50
Le Chatelier's High-temperature Measurements. (Boudouard—Burgess.).....	12mo,	3 00
Metcalf's Steel. A Manual for Steel-users.....	12mo,	2 00
Smith's Materials of Machines.....	12mo,	1 00

Thurston's Materials of Engineering. In Three Parts.....	8vo, 8 00
Part II.—Iron and Steel.....	8vo, 3 50
Part III.—A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	8vo, 2 50
Ulke's Modern Electrolytic Copper Refining.....	8vo, 3 00

## MINERALOGY.

Barringer's Description of Minerals of Commercial Value. Oblong, morocco, 2 50	
Boyd's Resources of Southwest Virginia.....	8vo, 3 00
Map of Southwest Virginia.....	Pocket-book form, 2 00
Brush's Manual of Determinative Mineralogy. (Penfield.).....	8vo, 4 00
Chester's Catalogue of Minerals.....	8vo, paper, 1 00
	Cloth, 1 25
Dictionary of the Names of Minerals .....	8vo, 3 50
Dana's System of Mineralogy.....	Large 8vo, half leather, 12 50
First Appendix to Dana's New "System of Mineralogy.".....	Large 8vo, 1 00
Text-book of Mineralogy.....	8vo, 4 00
Minerals and How to Study Them.....	12mo, 1 50
Catalogue of American Localities of Minerals.....	Large 8vo, 1 00
Manual of Mineralogy and Petrography.....	12mo, 2 00
Eakle's Mineral Tables.....	8vo, 1 25
Egleston's Catalogue of Minerals and Synonyms.....	8vo, 2 50
Hussak's The Determination of Rock-forming Minerals. (Smith.) Small 8vo, 2 00	
Merrill's Non-metallic Minerals: Their Occurrence and Uses.....	8vo, 4 00
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests.	8vo, paper, 0 50
Rosenbusch's Microscopical Physiography of the Rock-making Minerals.	
(Iddings.).....	8vo, 5 00
* Tillman's Text-book of Important Minerals and Docks.....	8vo, 2 00
Williams's Manual of Lithology.....	8vo, 3 00

## MINING.

Beard's Ventilation of Mines.....	12mo, 2 50
Boyd's Resources of Southwest Virginia.....	8vo, 3 00
Map of Southwest Virginia.....	Pocket-book form, 2 00
* Drinker's Tunneling, Explosive Compounds, and Rock Drills.	
	4to, half morocco, 25 00
Eissler's Modern High Explosives.....	8vo, 4 00
Fowler's Sewage Works Analyses.....	12mo, 2 00
Goodyear's Coal-mines of the Western Coast of the United States.....	12mo, 2 50
Ihlseng's Manual of Mining.....	8vo, 4 00
** Iles's Lead-smelting. (Postage 9c. additional.).....	12mo, 2 50
Kunhardt's Practice of Ore Dressing in Europe.....	8vo, 1 50
O'Driscoll's Notes on the Treatment of Gold Ores.....	8vo, 2 00
* Walke's Lectures on Explosives.....	8vo, 4 00
Wilson's Cyanide Processes.....	12mo, 1 50
Chlorination Process.....	12mo, 1 50
Hydraulic and Placer Mining.....	12mo, 2 00
Treatise on Practical and Theoretical Mine Ventilation.....	12mo 1 25

## SANITARY SCIENCE.

Copeland's Manual of Bacteriology. ( <i>In preparation.</i> )	
Folwell's Sewerage. (Designing, Construction and Maintenance.).....	8vo, 3 00
Water-supply Engineering.....	8vo, 4 00
Fuertes's Water and Public Health.....	12mo, 1 50
Water-filtration Works.....	12mo, 2 50

Goodrich's Economical Disposal of Town's Refuse.....	Demy 8vo,	3 50
Hazen's Filtration of Public Water-supplies.....	8vo,	3 00
Kiersted's Sewage Disposal.....	12mo,	1 25
Leach's The Inspection and Analysis of Food with Special Reference to State Control. ( <i>In preparation.</i> )		
Mason's Water-supply. (Considered Principally from a Sanitary Standpoint.) 3d Edition, Rewritten.....	8vo,	4 00
Examination of Water. (Chemical and Bacteriological).....	12mo,	1 25
Merriman's Elements of Sanitary Engineering .....	8vo,	2 00
Nichols's Water-supply. (Considered Mainly from a Chemical and Sanitary Standpoint.) (1883.).....	8vo,	2 50
Ogden's Sewer Design.....	12mo,	2 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Reference to Sanitary Water Analysis.....	12mo,	1 25
* Price's Handbook on Sanitation.....	12mo,	1 50
Richards's Cost of Food. A Study in Dietaries.....	12mo,	1 00
Cost of Living as Modified by Sanitary Science .....	12mo,	1 00
Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint.....	8vo,	2 00
* Richards and Williams's The Dietary Computer.....	8vo,	1 50
Rideal's Sewage and Bacterial Purification of Sewage.....	8vo,	3 50
Turneure and Russell's Public Water-supplies.....	8vo,	5 00
Whipple's Microscopy of Drinking-water.....	8vo,	3 50
Woodhull's Notes and Military Hygiene.....	16mo,	1 50

## MISCELLANEOUS.

Barker's Deep-sea Soundings.....	8vo,	2 00
Emmons's Geological Guide-book of the Rocky Mountain Excursion of the International Congress of Geologists.....	Large 8vo	1 50
Ferrel's Popular Treatise on the Winds.....	8vo	4 00
Haines's American Railway Management.....	12mo,	2 50
Mott's Composition, Digestibility, and Nutritive Value of Food. Mounted chart.		1 25
Fallacy of the Present Theory of Sound.....	16mo	1 00
Ricketts's History of Rensselaer Polytechnic Institute, 1824-1894. Small	8vo,	3 00
Rotherham's Emphasized New Testament.....	Large 8vo,	2 00
Steel's Treatise on the Diseases of the Dog.....	8vo,	3 50
Totten's Important Question in Metrology.....	8vo	2 50
The World's Columbian Exposition of 1893.....	4to,	1 00
Worcester and Atkinson. Small Hospitals, Establishment and Maintenance, and Suggestions for Hospital Architecture, with Plans for a Small Hospital.....	12mo,	1 25

## HEBREW AND CHALDEE TEXT-BOOKS.

Green's Grammar of the Hebrew Language.....	8vo,	3 00
Elementary Hebrew Grammar.....	12mo,	1 25
Hebrew Chrestomathy.....	8vo,	2 00
Gesenius's Hebrew and Chaldee Lexicon to the Old Testament Scriptures. (Tregelles.).....	Small 4to, half morocco,	5 00
Letteris's Hebrew Bible.....	8vo,	2 25

